Building Control & Process Automation

BL-IP, BU-HPMS

2Q 2013 v1.0

Building Control & Process Automation

Example Targeted Applications / End Equipments
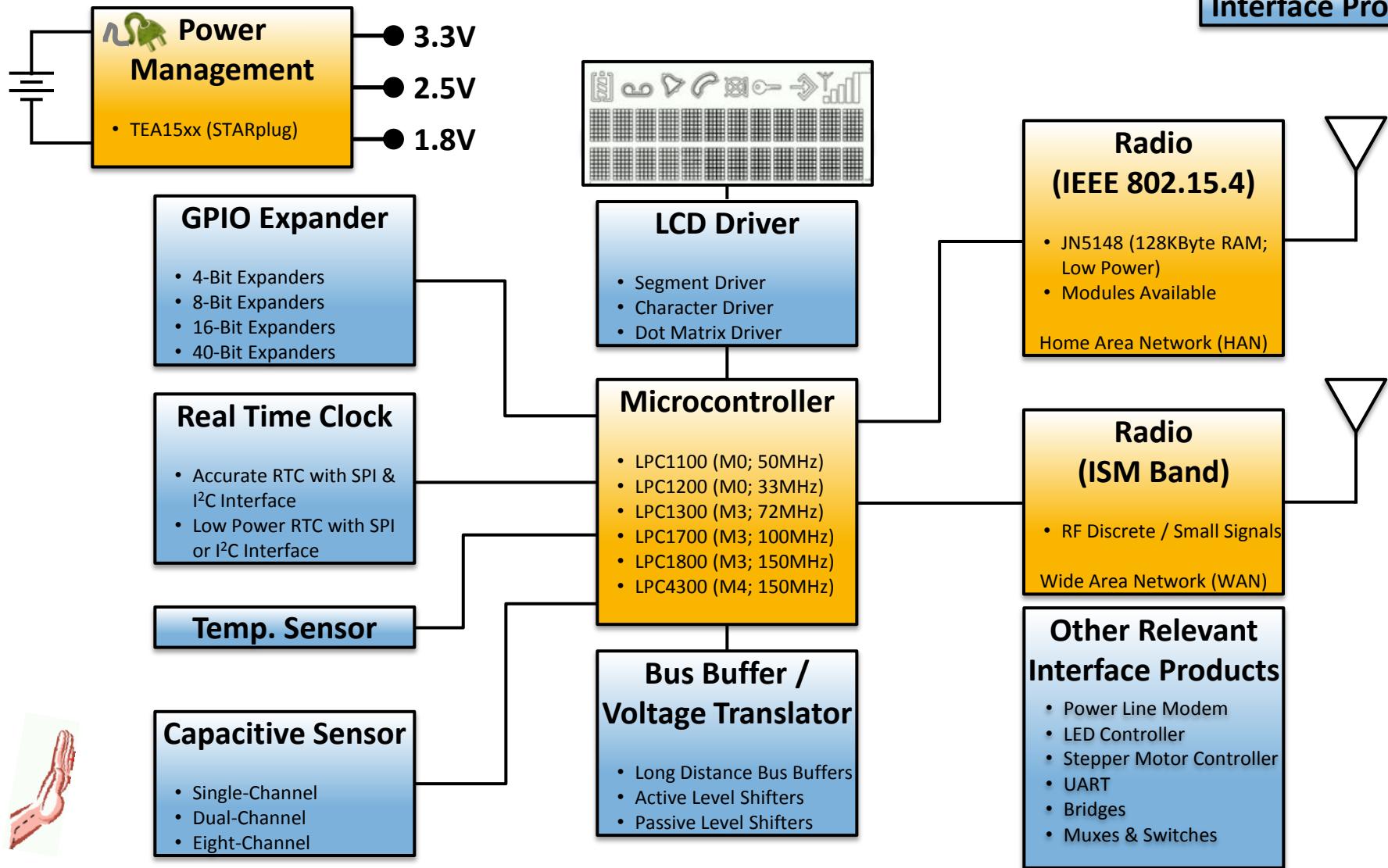
▸ Automated Building Thermostats

▸ HVAC Systems

▸ Building Security Systems

▸ Intrusion Systems & Alarms

▸ Low Cost Sensors

   – Leak Detectors

   – Occupation Sensors

▸ Energy Management

▸ Solar Panel Systems

▸ Smart Power Receptacles

▸ Lighting, Audio and Appliance Controllers

▸ Industrial Controllers

▸ Heating & Cooling Controllers

System Block Diagram

Power Management
- TEA15xx (STARplug)

3.3V
2.5V
1.8V

GPIO Expander
- 4-Bit Expanders
- 8-Bit Expanders
- 16-Bit Expanders
- 40-Bit Expanders

Real Time Clock
- Accurate RTC with SPI & I²C Interface
- Low Power RTC with SPI or I²C Interface

Temp. Sensor

Capacitive Sensor
- Single-Channel
- Dual-Channel
- Eight-Channel

LCD Driver
- Segment Driver
- Character Driver
- Dot Matrix Driver

Microcontroller
- LPC1100 (M0; 50MHz)
- LPC1200 (M0; 33MHz)
- LPC1300 (M3; 72MHz)
- LPC1700 (M3; 100MHz)
- LPC1800 (M3; 150MHz)
- LPC4300 (M4; 150MHz)

Bus Buffer / Voltage Translator
- Long Distance Bus Buffers
- Active Level Shifters
- Passive Level Shifters

Radio (IEEE 802.15.4)
- JN5148 (128KByte RAM; Low Power)
- Modules Available

Home Area Network (HAN)

Radio (ISM Band)
- RF Discrete / Small Signals

Wide Area Network (WAN)

Other Relevant Interface Products
- Power Line Modem
- LED Controller
- Stepper Motor Controller
- UART
- Bridges
- Muxes & Switches

Real Time Clocks

Standalone RTC Highlights

RTC Families:

• Lowest Power RTC Family	**PCF8523, PCF2123**	Ultra-low power, I²C or SPI Interface
• Low Cost, Low Power RTC Family	**PCF85063, PCF85063A, PCF85063B**	Low power, I²C or SPI Interface
• Accurate RTC Family	**PCF2127(A)T/2, PCF2129(A)T/2**	Highly accurate RTC, I²C and SPI Interface
• Automotive RTC Family	**PCA8565, PCA21125**	High temp. up to 125°C, I²C or SPI Interface
• Accurate/Automotive RTC Family	**PCA2129T/Q900/2**	Highly accurate and AEC-Q100 compliant

Key Features:

- Time keeping
- Low power; <100nA I_{CC} (PCF2123)
- Large voltage range; 1.5V to 5.5V
- Clock from seconds to 99 years
- Programmable Timer
- Frequency output
- Small packages (TSSOP8, HVSON10, etc)

RTC

32kHz Quartz — Oscillator/prescaler — CLKOUT → 0, 1, ..., 32768Hz

Supply → POR | Counters: s, min, h, day, month, year

Data I/O ↔ Interface I²C or SPI-bus | Timer- Registers → every second or every minute or timer

Interrupt →
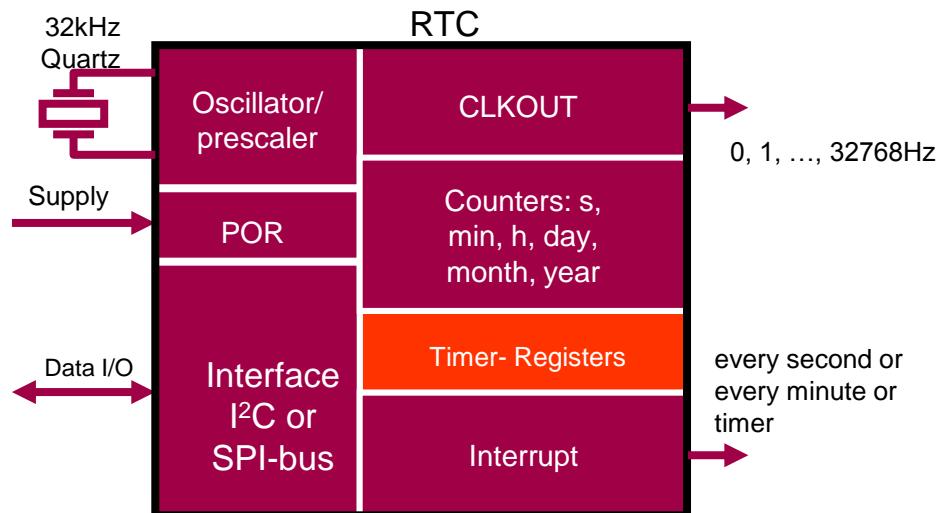
Value Proposition:

- For highly accurate time-keeping, choose NXP RTCs with as low as **±3ppm** accuracy
- For long battery life, chose NXP RTCs with the industry's lowest current consumption of less than **100nA**
- For rugged environment applications, there is no way around NXP RTCs with extended temperature range up to **125°C** and **AEC-Q100 automotive compliant qualification**

Key RTC Products

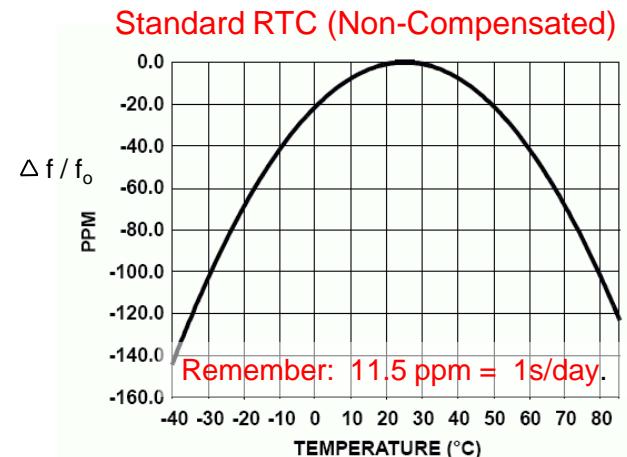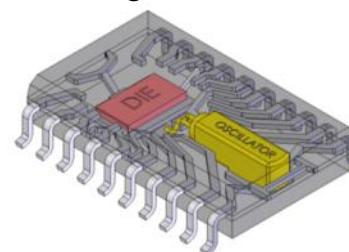|	Type	Interface	Package	Key features
Tiny	PCF85063 PCF85063A	I²C-Bus	HWSON8 HXSON10	Tiny Footprint, best cost, RTC only Tiny Footprint, best cost, RTC + Alarm
	PCF85063B	SPI Bus	HXSON10	Tiny Footprint, best cost, RTC + Alarm
Lowest Power	PCF2123	SPI Bus	TSSOP14, HVQFN16	Lowest power (100nA), electronic tuning
	PCF8523	I²C-Bus	SO8, TSSOP14 HVSON8,	Lowest power (100nA), electronic tuning Battery management
! !	PCF8563 /5	I²C-Bus	SO8, TSSOP8, HVSON8	Industry standard
Precise	PCF2129A, PCF2127A	I²C-Bus/ SPI Bus	SO20	High accuracy ±3ppm, -25°...+65°C Battery management, Time stamp, metal can quartz (PCF2127A features also 512byte RAM)
	PCF2129 PCF2127	I²C-Bus/ SPI Bus	SO16	High accuracy ±3ppm, -40°..+85°C Battery management, Time stamp, ceramic quartz (PCF2127 features also 512byte RAM)
Automotive	PCA8565	I²C-Bus	TSSOP8, HVSON10*	Robustness: up to 125°C
	PCA21125	SPI Bus	TSSOP14	Robustness: up to 125°C
	PCA2129	I²C-Bus/ SPI Bus	SO16	High accuracy ±3ppm, Battery management, Time stamp, ceramic quartz for automotive

* HVSON10 package variant is not automotive grade

PCF2127A / 29A:
Low-Power Accurate Real Time Clock (aRTC)

Features and Benefits

- High accuracy **(±3ppm**; typ.) for accurate time reference

- Ultra-low power consumption enables long battery life
  - ~500nA @ V_{DD}=2.0V and Tamb=25ºC

- Integrated quartz crystal requires no external quartz

- Integrated TCXO with temperature compensation circuit requires no external temperature sensor and no temperature dependent tuning

- Battery backup and switchover functionality ensures reference timekeeping during power down

- Factory calibrated and ready at very first power up

- No external capacitors required and no re-calibration required to compensate for aging

- Integrated 512-byte RAM (PCF2127A) for retaining critical data during power down

- SPI and I²C Interface

- SO20 Package

- AEC Q100 Compliant (PCA2129T/Q900)

Standard RTC (Non-Compensated)

$\Delta f / f_o$

Remember: 11.5 ppm = 1s/day.

Accurate RTC (Compensated)

$\Delta f / f_o$

Typical Error: Only ±3ppm over -15°C to 60°C
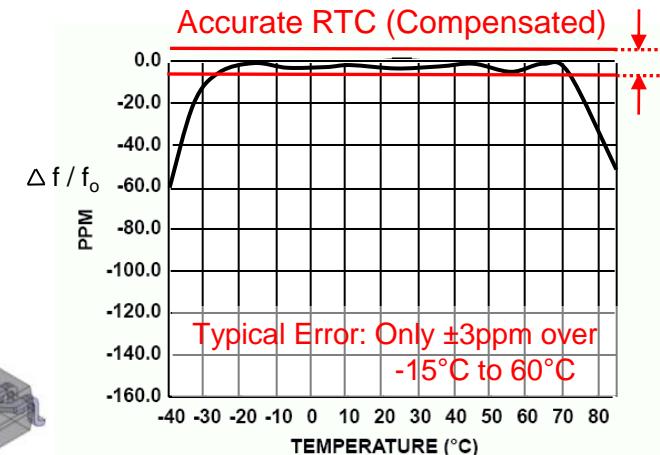
PCF2127(A) / 29(A): Differences in Accuracy

Key features:

The PCx2129 comprises a Real Time Clock (RTC) and a temperature compensated quartz oscillator (TCXO). The quartz crystal itself is integrated into the package.

There are 2 major version one in SO20, the other one in SO16. They feature different frequency response.

Type number	PCF2127AT, 2129AT	PC2127T/2, 2129T
Version	Industrial	Industrial
Grade	General Quality spec **GQS**	General Quality spec **GQS**
Frequency accuracy	+/- 5ppm -15°C…+60°C +/-10ppm -25..-15, 60..65°C	+/- 8ppm -30°C…+80°C +/-15ppm <-30°C, >80°C
Construction	Metal can quartz	Ceramic quartz
Silicon foundry Assembly fab Wafer and final test	TSMC Taiwan APB Bangkok Thailand APB Bangkok Thailand	TSMC Taiwan APB Bangkok Thailand APB Bangkok Thailand
Release status	**Released**, mass production	**Release**, mass production
Package	**SO20**	**SO16** drop-in compliant to SO20
Quartz Type		
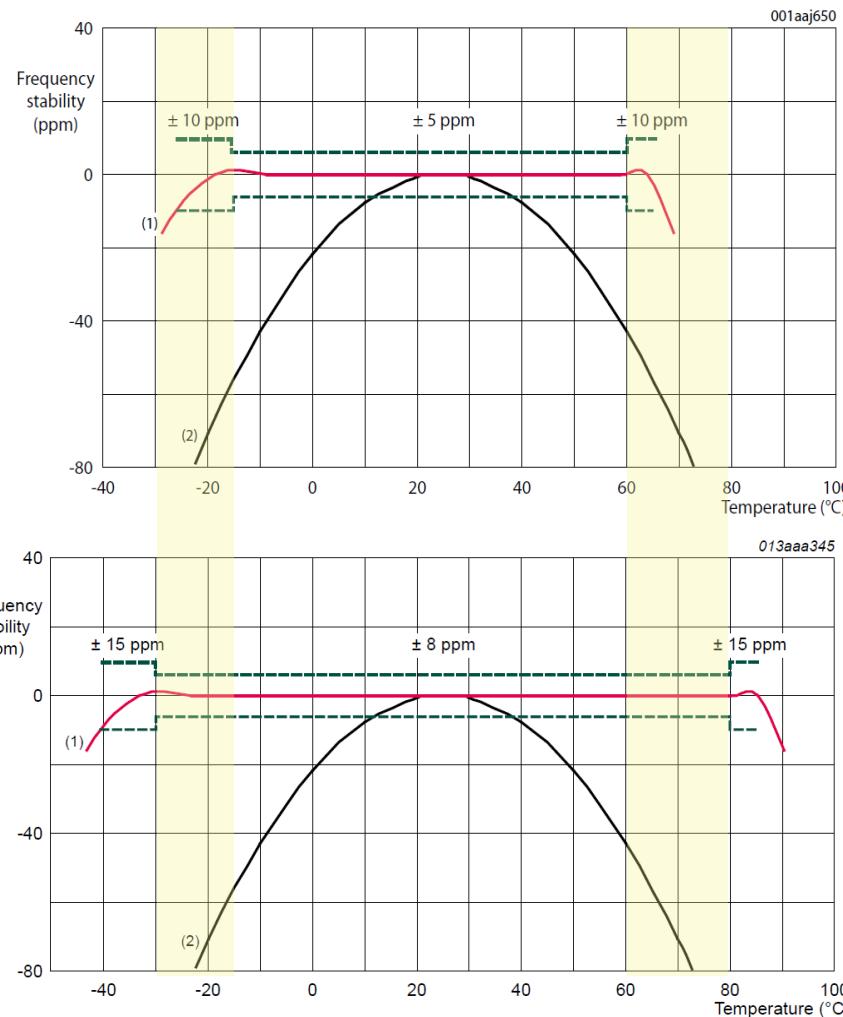
PCF2123: Ultra-low Power RTC with SPI Interface

▸ **Supply current as low as 100nA** (typ.) at VDD = 2.0V and T_{amb} = 25 ºC

Key Features:

▸ Ultra low power 100nA @ 2V (typ.)

▸ Large voltage range 1.5…5.5V

▸ SPI bus up to 6MHz

▸ Clock from seconds to 99 years

▸ Programmable Countdown Timer

▸ Programmable Output Clock Frequency with Output Enable pin

▸ **Electronic tuning**

▸ Small packages TSSOP14, HVQFN16 and U (die only)
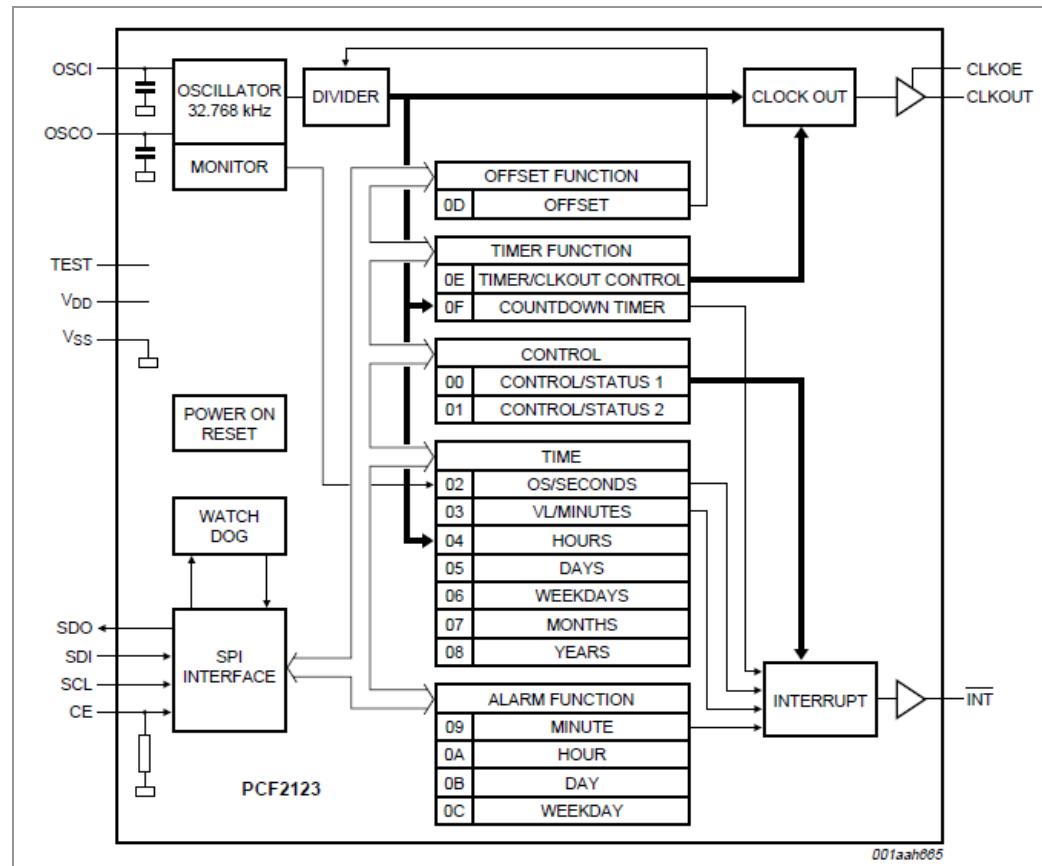
PCF8523: Ultra-low Power RTC with I^{2}C Interface

▸ **Supply current as low as 150nA** (typ.) at VDD = 3.0V and T_{amb} = 25 °C

Key Features:

▸ Ultra low power **150nA @ 3V** (typ.)

▸ Large voltage range 1.6…5.5V

▸ 1MHz Fast-mode Plus (Fm+) I^{2}C Interface

▸ Clock from seconds to 99 years

▸ Programmable Countdown Timer

▸ Programmable output clock

▸ **Power Fail Detection Function**

▸ **Battery Switch-Over Function**

▸ **Battery Low Detection Function**

▸ **Electronic Tuning**

▸ Packages: SO8, TSSOP14, HVSON8 & U

Standard mode

Direct switching mode
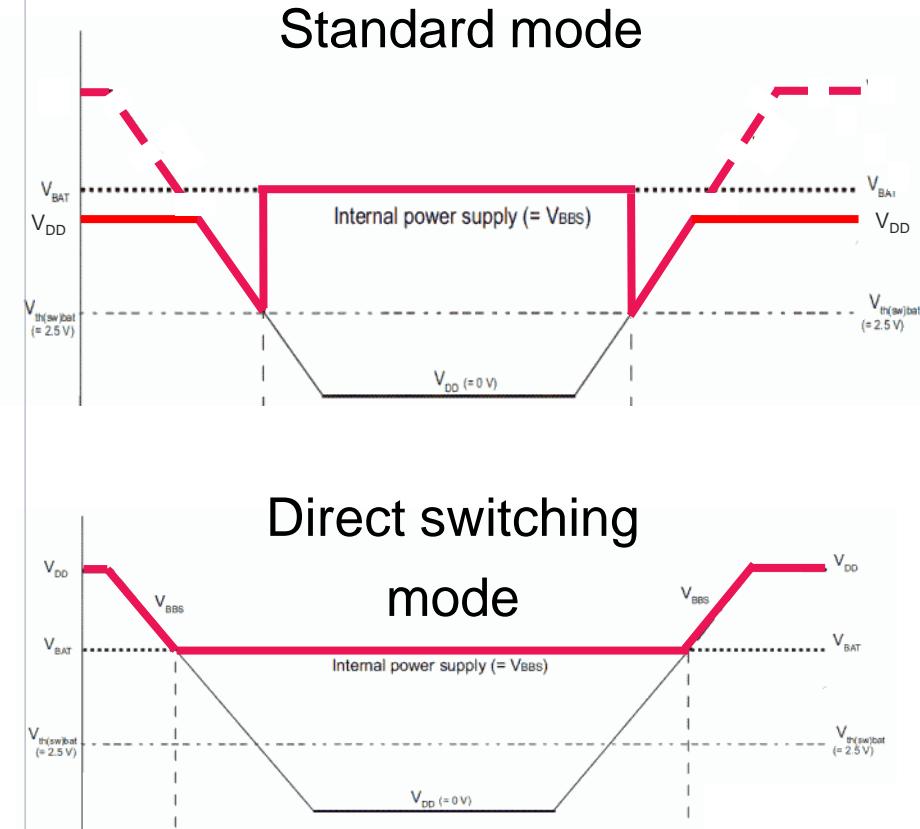
PCF85063: Small Footprint Low-Power RTC

- ▶ Available Versions:
  - PCF85063TP: I^2C-bus, Limited feature set, 8-pin package
  - PCF85063ATL: I^2C-bus, Full feature set, 8-pin package
  - PCF85063BTL: SPI-bus, Full feature set + CLKOUT, 10-pin package

- ▶ Features
  - Low-power consumption; At V_{DD}=2.0V, T_{AMB}=25 °C, no bus activity and CLKOUT active, I_{DD}=260 nA (typ)
  - Very small footprint packages
    - HXSON8, 2.1 x 3.1 x 0.5mm; 0.5-mm pitch
    - HXSON10, 2.7 x 2.7 x 0.5mm; 0.5-mm pitch
  - Two interfaces supported; I^2C and SPI
  - Two integrated programmable oscillator capacitors
    - For 7-pF load
    - For 12-pF load

- ▶ Target Applications
  - Thermostats
  - Lighting Controllers
  - Remote Sensors
  - Security Systems
  - Intrusion Alarms

Function	PCF85063TP	PCF85063ATL	PCF85063BTL
Electronic tuning	Yes	Yes	Yes
I^2C-bus SPI interface	✓	✓	✓
1 min interrupt	No	Yes	Yes
Alarm facility Timer	No No	Yes Yes	Yes Yes
CLK out CLK enable Interrupt output	Yes No Yes	Yes Yes Yes	Yes Yes Yes
Package SOT number	HXSON-8 [1] SOT1052	HXSON-8 [1] SOT1052	HXSON-10 [1] SOT1197

[1] 0.5-mm pitch

Capacitive Sensor

Capacitive Sensors Value Proposition

▸ **Why used?**
- No contact required (no actual pressing on touch area)
- Works even when wearing gloves
- Works in dirty environment (self-calibrating)
- Works together with any event that generates a pre-defined change in capacitance
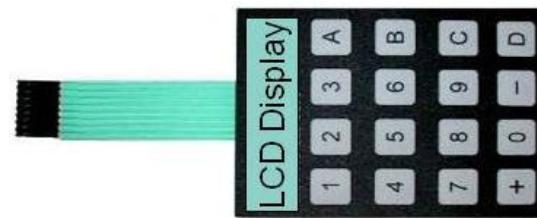
▸ **Where used?**
- Switches for use in building lighting, fans, blinds, etc.
- Switches in medical and industrial environment
- Sanitary applications like in public rest rooms
- Proximity detection (tamper-proof) in embedded equipment

▸ **Why NXP?**
- Products are very sensitive, highly configurable and consumes low power

Capacitive Sensor Portfolio

Single Channel	Dual Channel	Eight Channel

PCF8883
• One input one output
• Does not require a microcontroller
• Available in two packages
   • PCF8883T (SOIC8)
   • **PCF8883US (WLCSP8)**
	PCA8886
	• Two inputs, two outputs
	• Does not require a microcontroller
	• May be used for up to 3 sensors
	• AEC-Q100 compliant
	• Available in TSSOP16 (PCA8886TS/Q900/1)
		PCA8885 and PCF8885
		• 8-Channels
		• Requires a microcontroller
		• May be configured for up to 28 sensors
		• With two devices, user may enable up to 80 sensors
		• Available as both industrial and automotive versions in TSSOP28
		• Industrial version also available in SOIC28 package. MLF 28-pin package under consideration.

PCF8883: Single-Channel Proximity/Touch Switch

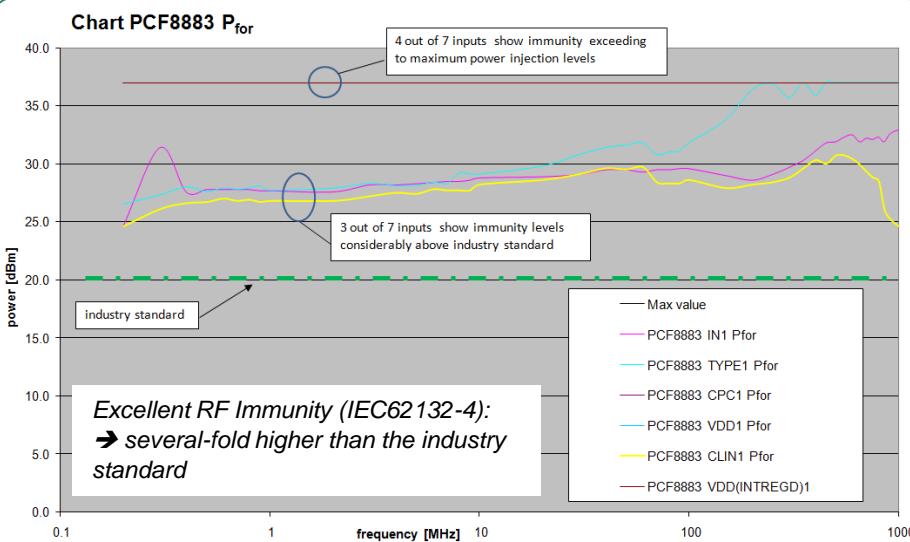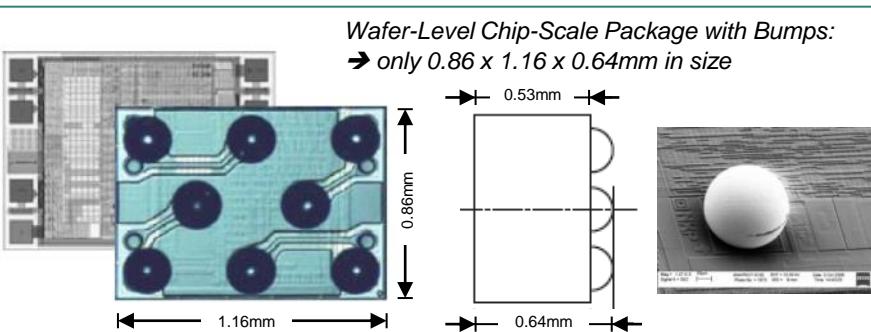| Touch Sensor	
PCF8883	Self calibrating touch switch, SO8

▸ Touch/Proximity Switch for User Interface
  – Replacement of mechanical switches
  – No need for mechanical opening or cleaning surface
  – Hygienic aspect
  – **Auto (self) calibrating disregards contamination**
  – No wear out of contact
  – Single channel device

▸ Superior Device Specification
  – Digital processing method
  – Open-drain output (P-type MOSFET, external load between pin and GND)
  – Output configurable as push-button, toggle or switch
  – **Low-power battery operation possible ($I_{DD} < 5\mu A$)**
  – Extended battery-voltage operating range ($2.8V < V_{DD} < 9V$)
  – Adjustable response time and sensitivity
 – Patented algorithm which offers best performance

Sensing plate (capacitor plate 1)
„dielectric"
Activator (capacitor plate 2)

000aaa-001
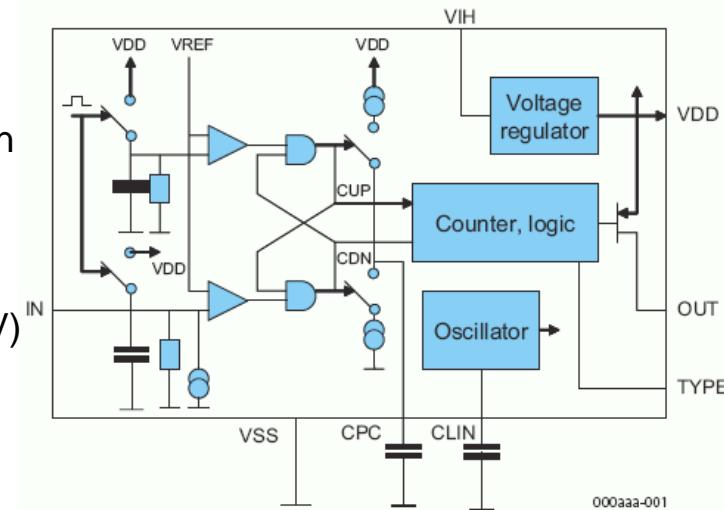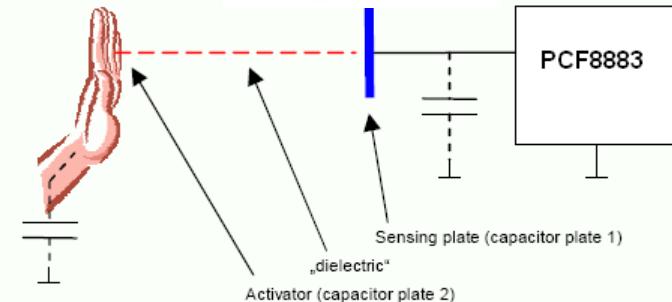
PCF8883: Single-Channel Capacitive Sensor

➢ *Patented (EDISEN) digital method to detect a change in capacitance on a remote sensing plate.*

  ➔ *Changes in the static capacitance (as opposed to dynamic capacitance changes) are automatically compensated using continuous auto-calibration.*

➢ *Auto-calibration filters out contamination on sensor*

  ➔ *no microcontroller recalibrations necessary*

  ➔ *water droplets on top of a sensor plate will not cause false switching*

➢ *Excellent RF Immunity (in accordance with IEC62132-4)*

  ➔ *The direct RF power injection (DPI) method shows an RF immunity several-fold higher than industry standard*

➢ *Ultra-low power consumption of $3\mu A$ (typ.)*

  ➔ *¼ of the power consumption of the nearest competitor*

➢ *Available in Wafer-Level-CSP with bumps:*

  ➔ *only 0.86 x 1.16 x 0.64mm in size*

  ➔ *for reflow soldering and in tape and reel*

Wafer-Level Chip-Scale Package with Bumps:
➔ *only 0.86 x 1.16 x 0.64mm in size*

0.53mm

0.86mm

1.16mm

0.64mm

Chart PCF8883 P$_{for}$

4 out of 7 inputs show immunity exceeding to maximum power injection levels

3 out of 7 inputs show immunity levels considerably above industry standard

industry standard

power [dBm]

frequency [MHz]

Max value
PCF8883 IN1 Pfor
PCF8883 TYPE1 Pfor
PCF8883 CPC1 Pfor
PCF8883 VDD1 Pfor
PCF8883 CLIN1 Pfor
PCF8883 VDD(INTREGD)1

Excellent RF Immunity (IEC62132-4):
➔ *several-fold higher than the industry standard*

Auto-calibration:
➔ *Water droplets on top of the sensor plate will not cause false switching*
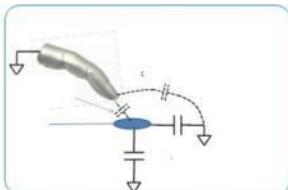
Patented (EDISEN) digital method:
➔ *static capacitance changes are filtered out; dynamic capacitance changes are processed*

PCF8883: Evaluation Kit (OM11055)

▸ Allows tuning of external components

▸ Inclusion of op-amp allows measuring the voltage on C_{CPC} without disturbing the loop

▸ Several sensor plate sizes to evaluate

▸ Power supply via USB or battery (USB cable included)

▸ Support documents:
  – AN10832:   PCF8883 – Capacitive Proximity Switch with Auto-Calibration
  – UM10370:   User Manual for the PCF8883 Evaluation Kit OM11055
  – Datasheets: PCF8883, PCA8886

▸ Reconfigurable TYPE Input to support push-button, toggle and pulse output signals
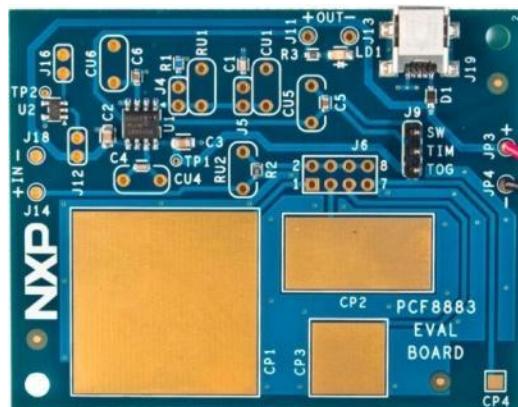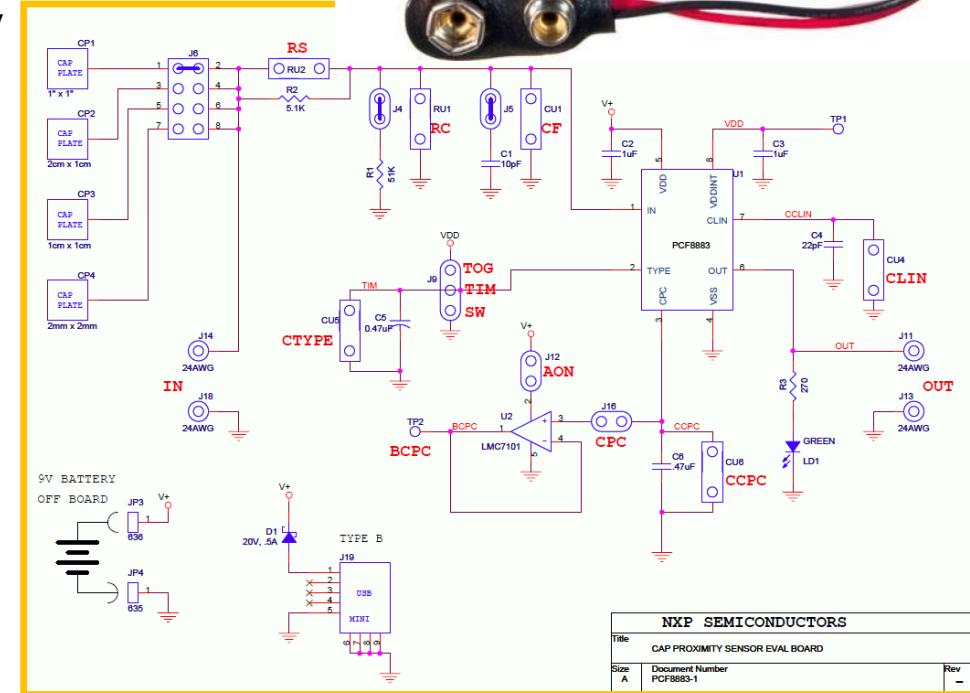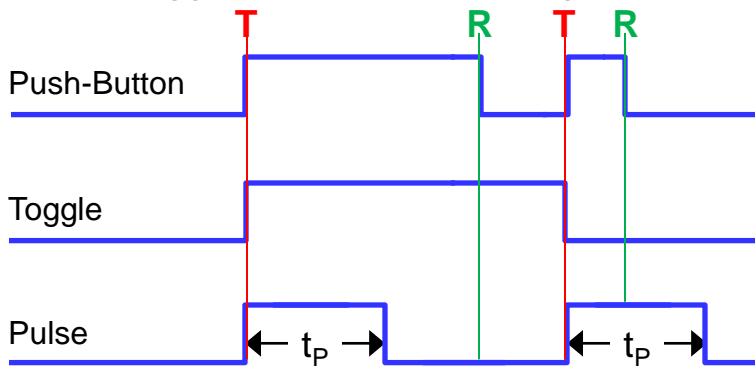
PCA8886: Dual-Channel Proximity/Touch Switch

Touch Sensor	
PCA8886	Self calibrating touch switch, TSSOP16

▸ Features
- Dynamic proximity switch
- Adjustable sensitivity
- Adjustable response time
- Wide input capacitance range (10pF to 60pF)
- Automatic calibration
- Large distance (several meters) between sensing plate and IC is possible
- Low power consumption ($I_{DD} = 6\mu A$)
- Open-drain output configurable as push-button, toggle, or pulse
- Extended battery-voltage operating range ($3V < V_{DD} < 9V$)
- Patented algorithm which offers best performance

C_{SENS} = sensing plate capacitance.
The coaxial cable is optional.

PCF8883   +   PCF8883   =   PCA8886
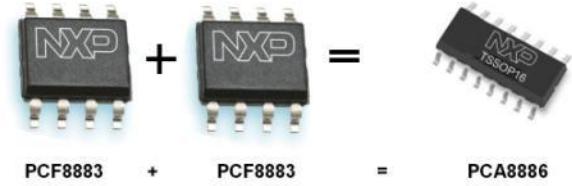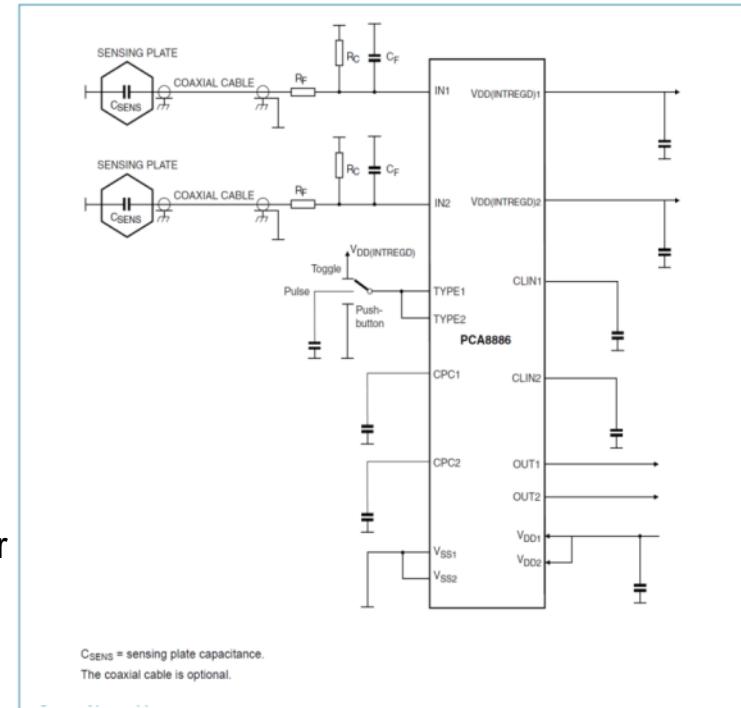
PCA8886: Application Board (OM11052)

- ▸ Detects proximity and touch
- ▸ Demonstrates door handle activation with proximity sensing
- ▸ Proofs high immunity to environmental changes with measurements performed from -40 °C to +85 °C
  - – Operates even with build-up ice on the door handle in the chamber at -40 °C.
  - – Operates even with mixture of condensation and ice on the door handle when moved to room conditions.
- ▸ Two touch areas are active
  - – Touch sensor with small area on the top side
  - – Proximity sensor with large area on the bottom side
- ▸ Support document:
  - – UM10711:   Slim Proximity Touch Sensor Demo Board OM11052
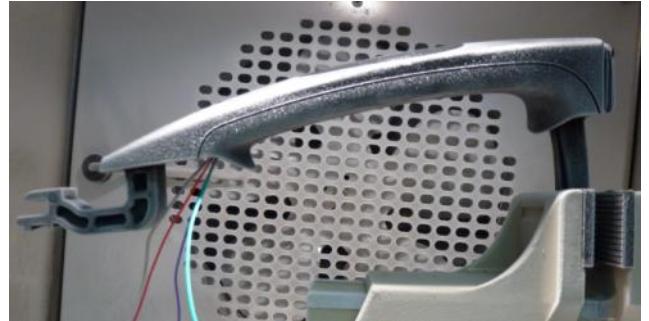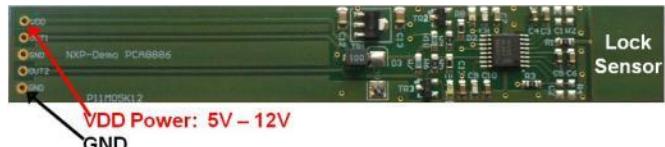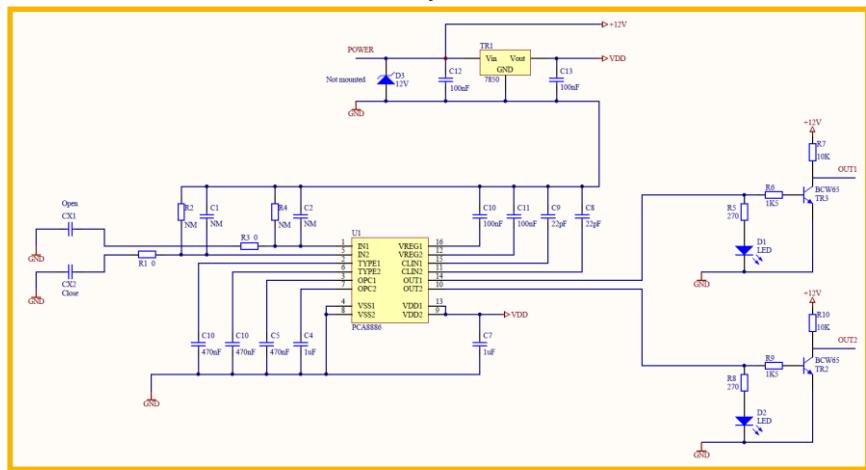
PC$_A^F$8885: 4x4 Channel Capacitive Sensor
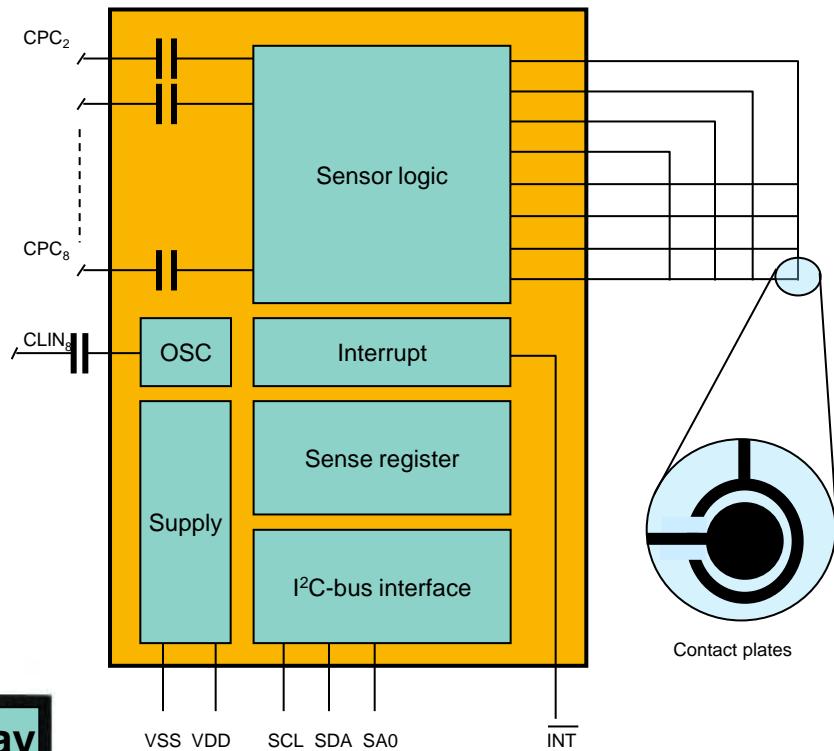
▸ Key Features:
  – Based on the PCF8883 algorithm
  – I^{2}C-bus interface
  – Adjustable scanning frequency
  – Channel masking feature
  – Fast start-up mode
  – One sub-address enables 2 devices per bus
  – Sleep mode, activated via I^{2}C bus or external input
  – Three sensing modes; one key, two keys and N-keys
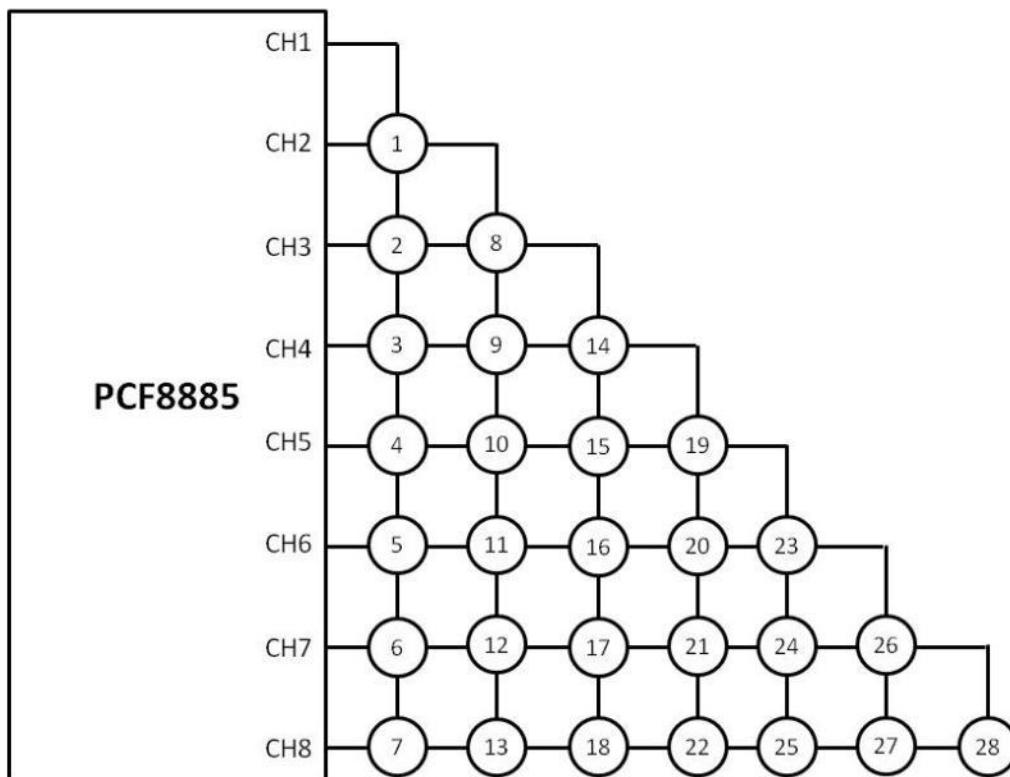 – Two events handling modes; direct and latching modes

▸ Benefits:
  – Address pin enables cascading of two devices and achieving up to 80 keys

▸ Applications:
  – Switchless keypads

Contact plates

LCD Display

PCF8885: Single Device with up to 28 Sensors

PCF8885

Diagram showing channels CH1–CH8 connected to sensors 1–28 in a triangular matrix.

	Inputs							
	b7	b6	b5	b4	b3	b2	b1	b0
1	0	0	0	0	0	0	1	1
2	0	0	0	0	0	1	0	1
3	0	0	0	0	1	0	0	1
4	0	0	0	1	0	0	0	1
5	0	0	1	0	0	0	0	1
6	0	1	0	0	0	0	0	1
7	1	0	0	0	0	0	0	1
8	0	0	0	0	0	1	1	0
9	0	0	0	0	1	0	1	0
10	0	0	0	1	0	0	1	0
11	0	0	1	0	0	0	1	0
12	0	1	0	0	0	0	1	0
13	1	0	0	0	0	0	1	0
14	0	0	0	0	1	1	0	0
15	0	0	0	1	0	1	0	0
16	0	0	1	0	0	1	0	0
17	0	1	0	0	0	1	0	0
18	1	0	0	0	0	1	0	0
19	0	0	0	1	1	0	0	0
20	0	0	1	0	1	0	0	0
21	0	1	0	0	1	0	0	0
22	1	0	0	0	1	0	0	0
23	0	0	1	1	0	0	0	0
24	0	1	0	1	0	0	0	0
25	1	0	0	1	0	0	0	0
26	0	1	1	0	0	0	0	0
27	1	0	1	0	0	0	0	0
28	1	1	0	0	0	0	0	0

‣ Sensors 1 to 28 are each connected to two channels

  ‣ Sensor 1 is connected to CH1 & CH2

  ‣ Sensor 2 is connected to CH1 & CH3

  ‣ Sensor 8 is connected to CH2 & CH3

‣ Total of 28 Sensors

‣ Device should be used in the 2-key mode

‣ After reading the SENS register, from the two bits set, the user can infer which sensor is touched.

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# PC_A^F8885: Cascading Application
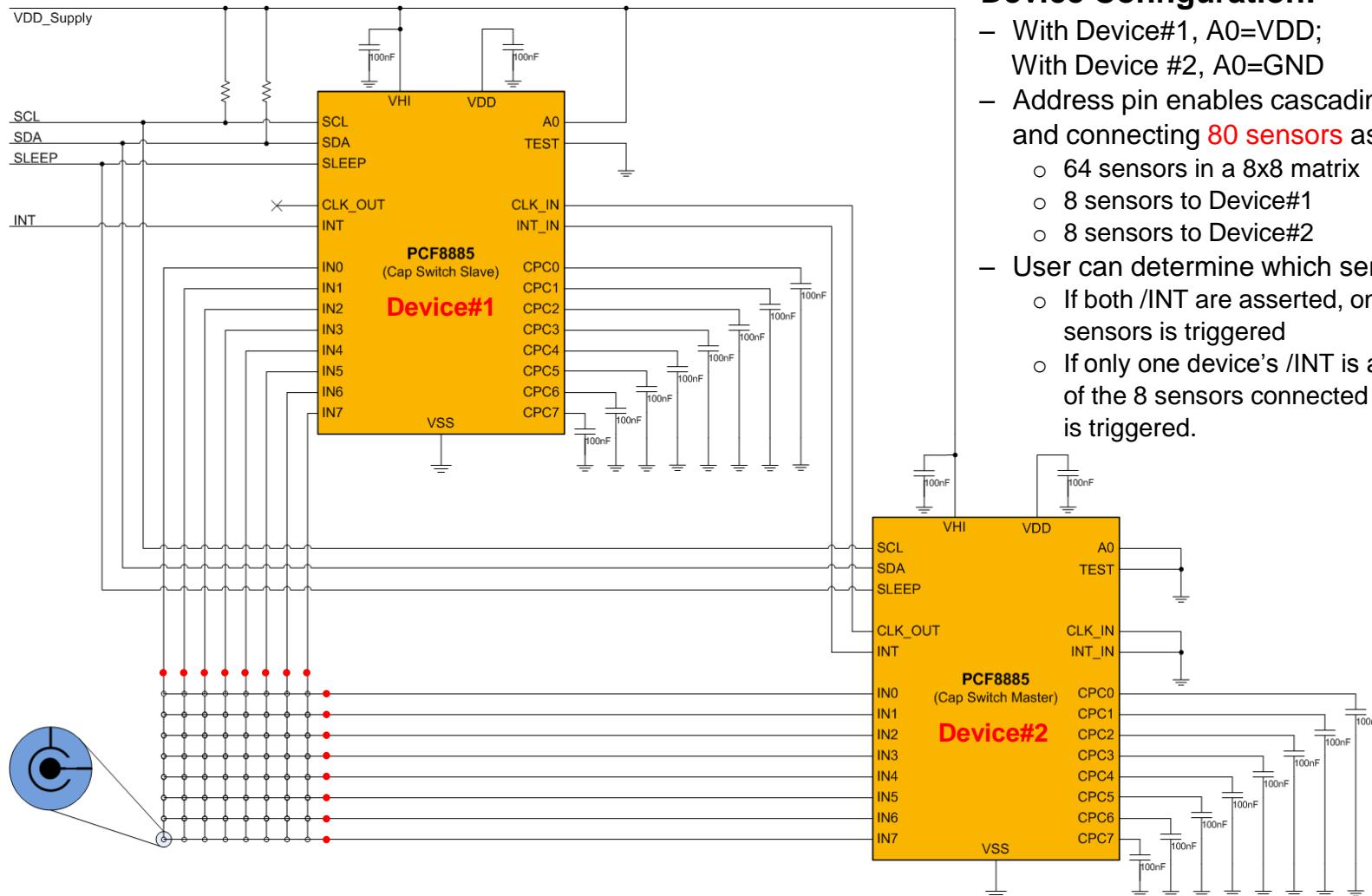
Device Configuration:

- With Device#1, A0=VDD;
  With Device #2, A0=GND
- Address pin enables cascading of two devices
  and connecting 80 sensors as follows:
  - 64 sensors in a 8x8 matrix
  - 8 sensors to Device#1
  - 8 sensors to Device#2
- User can determine which sensor is triggered
  - If both /INT are asserted, one of the 64
    sensors is triggered
  - If only one device's /INT is asserted, then one
    of the 8 sensors connected only to the device
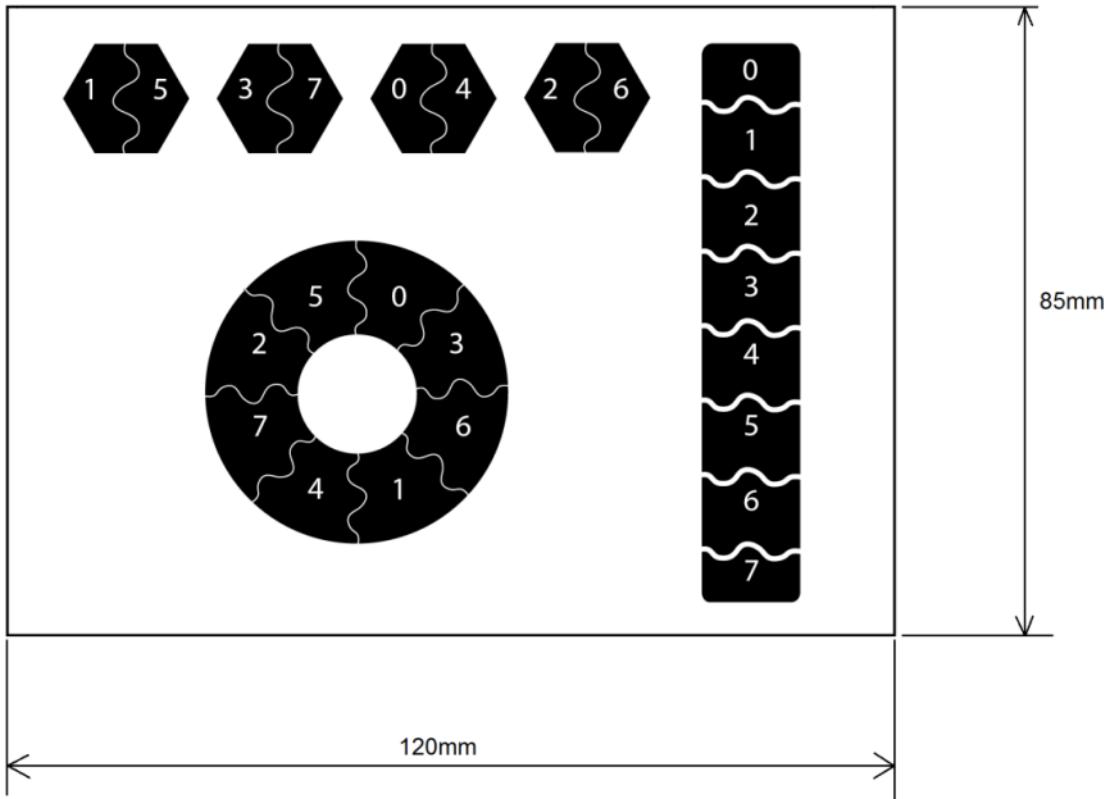   is triggered.

PCF8885 / PCA8886: Evaluation Kit (OM11057)

- ‣ Demonstrates the use of a single PCF8885 device in a multiplexed mode to achieve up to 28 sensors (19 sensors used on the board)

- ‣ Implements four touch buttons, a wheel and a slider

- ‣ Operates the PCF8885 in the 2-key mode and use the 2 out-of 8 code to enable 19 different sensor locations (7 for the slider, 8 for the wheel and 4 buttons)

- ‣ Enables touch sensitivity through a 3-mm acrylic overlay plate

- ‣ Uses the PCA8886 device in a proximity sensor mode to wake up board only when in use and demonstrates power saving features

- ‣ Feedback with a piezoelectric sound buzzer

- ‣ Feedback with RGB LED's

- ‣ Support documents:
  - – UM10505: OM11057 Quick Start Guide
  - – AN11122: Water and Condensation Safe Touch Sensing with the NXP Capacitive Touch Sensor
  - – AN11155: General Design Guidelines for the NXP Capacitive Sensors
  - – AN11157: Capacitive Touch Sensing with High EMC Performance
 - – Datasheets: PCF8885, PCA8886, PCF8536
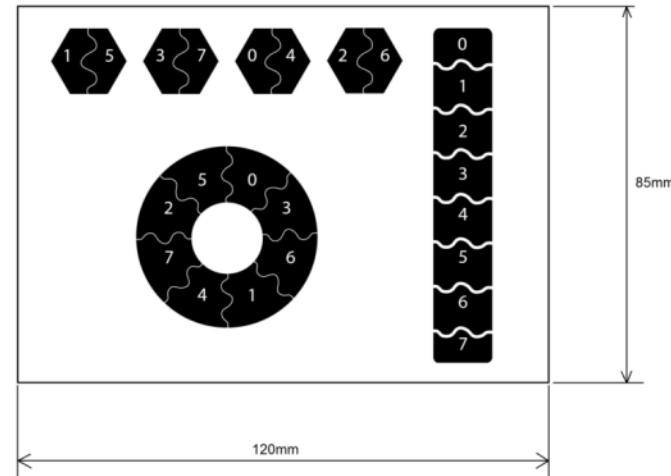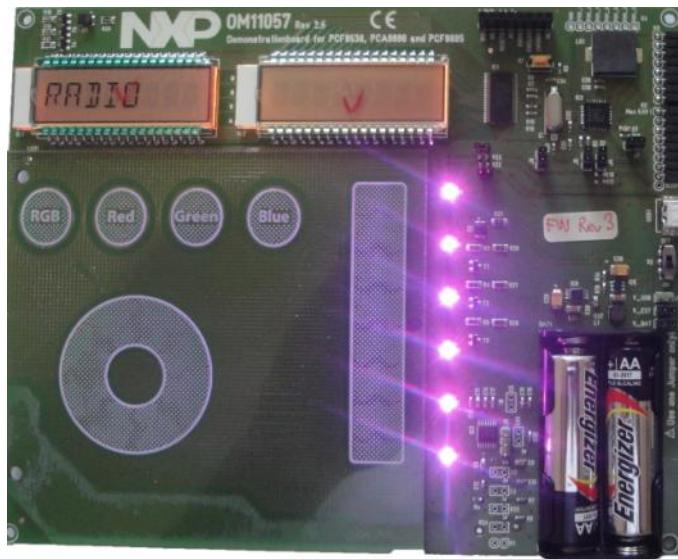
PCF8885 / PCA8886: Evaluation Kit (OM11057)

▸ The 2-out-8 code was exploited to enable 19 different combinations in the command area

▸ 7 for the slider, 8 for the wheel and 4 buttons

	b7	b6	b5	b4	b3	b2	b1	b0
1	0	0	0	0	0	0	1	1
2	0	0	0	0	0	1	0	1
3	0	0	0	0	1	0	0	1
4	0	0	0	1	0	0	0	1
5	0	0	1	0	0	0	0	1
6	0	1	0	0	0	0	0	1
7	1	0	0	0	0	0	0	1
8	0	0	0	0	0	1	1	0
9	0	0	0	0	1	0	1	0
10	0	0	0	1	0	0	1	0
11	0	0	1	0	0	0	1	0
12	0	1	0	0	0	0	1	0
13	1	0	0	0	0	0	1	0
14	0	0	0	0	1	1	0	0
15	0	0	0	1	0	1	0	0
16	0	0	1	0	0	1	0	0
17	0	1	0	0	0	1	0	0
18	1	0	0	0	0	1	0	0
19	0	0	0	1	1	0	0	0
20	0	0	1	0	1	0	0	0
21	0	1	0	0	1	0	0	0
22	1	0	0	0	1	0	0	0
23	0	0	1	1	0	0	0	0
24	0	1	0	1	0	0	0	0
25	1	0	0	1	0	0	0	0
26	0	1	1	0	0	0	0	0
27	1	0	1	0	0	0	0	0
28	1	1	0	0	0	0	0	0

85mm

120mm

PCF8885: Plug-In Daughter Card (OM11057A)

- Multi-channel capacitive sensor plug-in board with two PCF8885 and one PCA9535 devices
  - One PCF8885 device used for touch buttons
  - One PCF8885 device used for slider
  - PCA9535 device used to drive LED's

- Board plugs into Evaluation kit (OM11057)

- Enables touch sensitivity through a 10-mm thick polycarbonate panel, acrylic overlay plate, or another insulating material

- Connector allows access to VDD, GND, I^{2}C signals, and interrupt to enable system development and evaluation
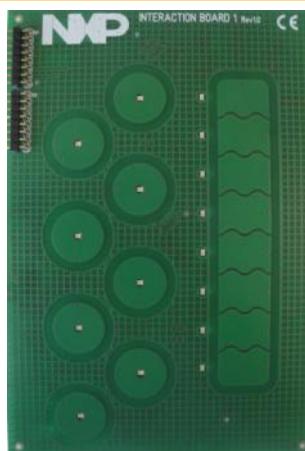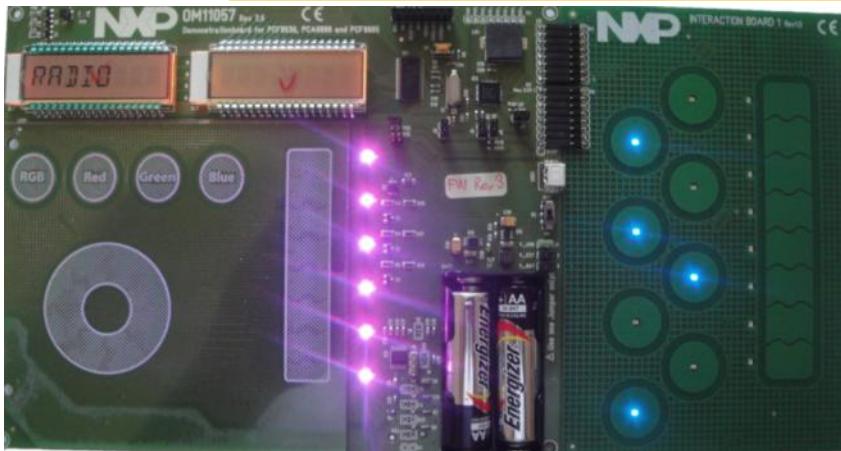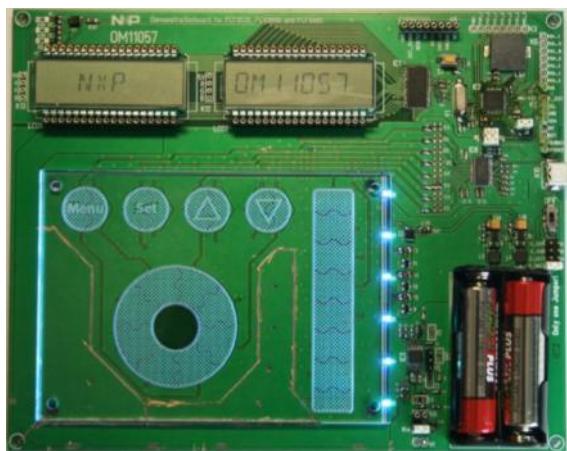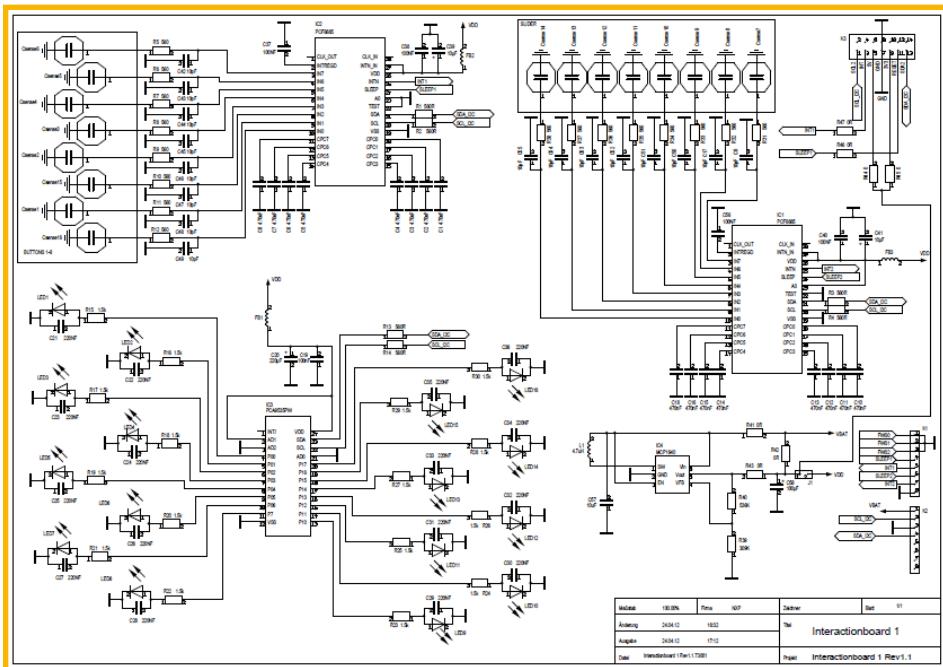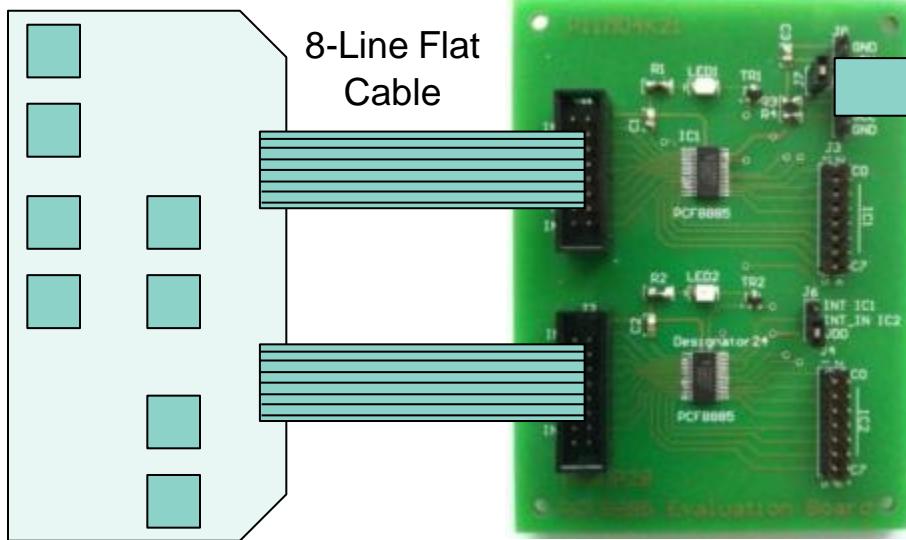
PCx8885: Evaluation Board ([OM11056](#))

▸ PCF8885 or PCA8885 evaluation board with two TSSOP 28-pin sockets

▸ Can be directly connected to the I2C-bus and attached to the sensor plates in the customer's application

▸ Support document:
  – [UM10664](#):   PCA8885 and PCF8885 Evaluation Board OM11056
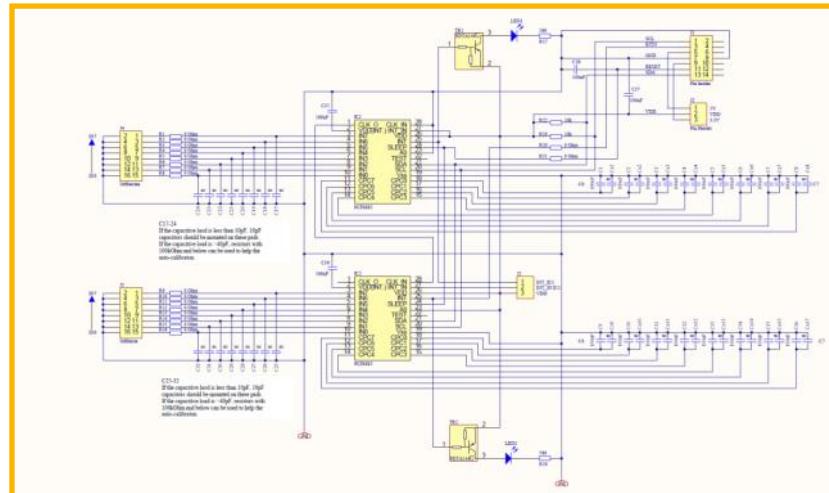
Custom Sensing Board

PCx8885 Evaluation Board
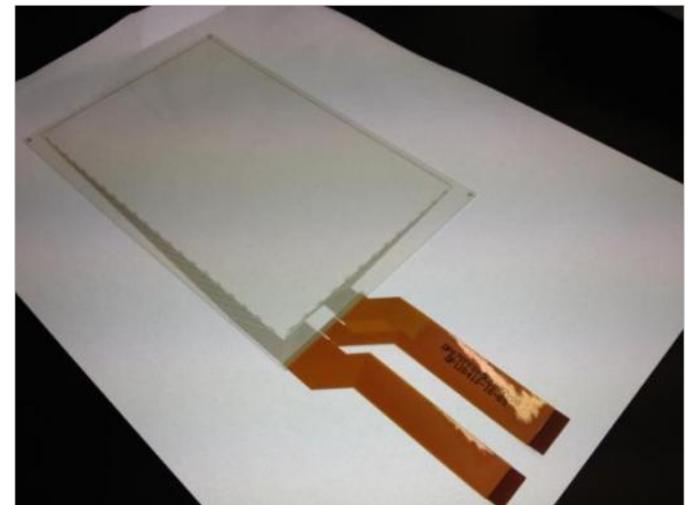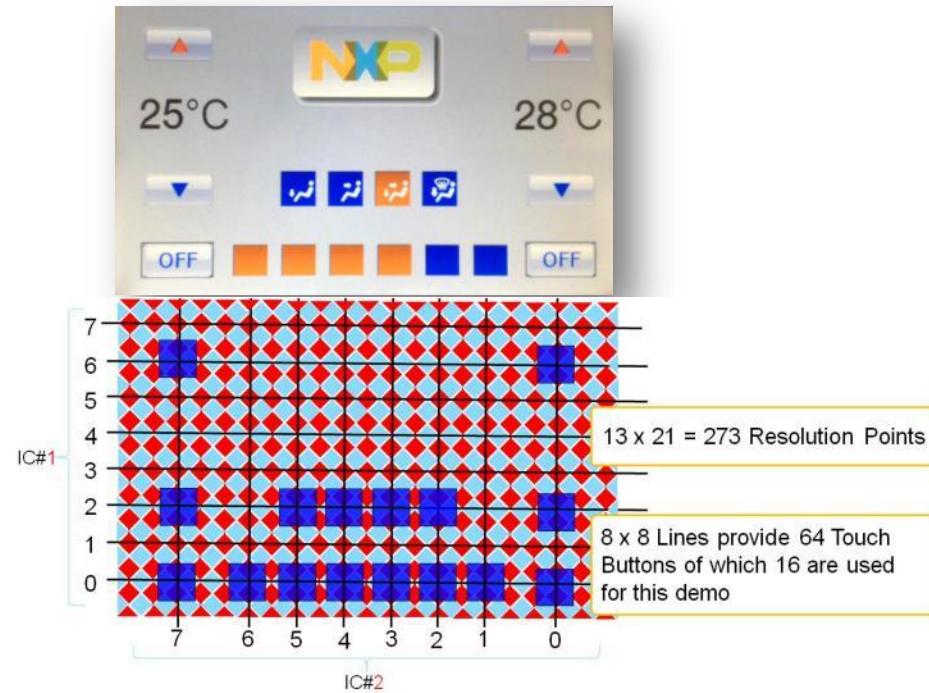
8-Line Flat Cable

I²C-bus

USB to I²C-Bus Translator

PCF8885: Touch Panel Demonstrator (OM11058)

Key Features:

‣ 7-Inches Capacitive Touch Panel from Dytos glued on top of a standard TFT display

‣ Two PCF8885 devices connected to a touch foil to detect 64 sensor areas (16 of 64 sensors are used in this demo)

‣ LPC1768 and emWIN used to generate Graphics and GUI

‣ Prototype available now

13 x 21 = 273 Resolution Points

8 x 8 Lines provide 64 Touch Buttons of which 16 are used for this demo

LCD Drivers

LCD Driver Value Proposition

▶ **Where used?**
- Thermostats / HVAC
- Intrusion & Building Security Systems
- Lighting Remote Controls
- Energy Meters & Energy Management Controllers

▶ **Segment Drivers' Key Features**
- Low power & driving up to 640 segments
- Standalone – no need for external components
- I²C and SPI interfaces available
- AEC-Q100 options
- Cascadable

▶ **Character Drivers' Key Features**
- Combines low power segment display with sophisticated 2-line character display
- Integrated generation of V_{LCD} with temperature compensation
- Very low power consumption (20 to 200µA)
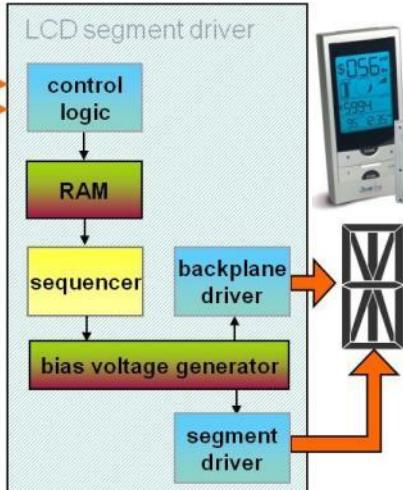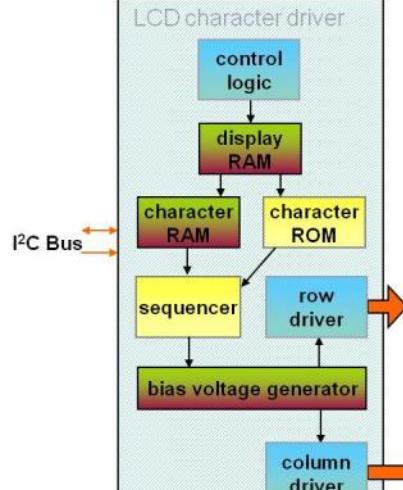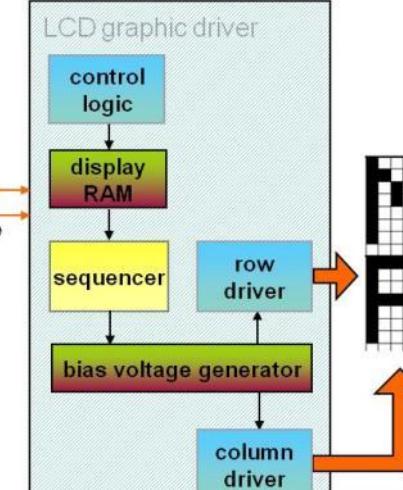- Display shift or static display modes
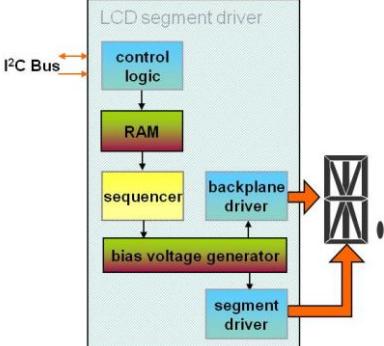
▶ **Graphic Drivers' Key Features**
- On-chip generation of LCD bias voltages
- Low number of external components
- Low power consumption

LCD Drivers: Differentiations

Segment Drivers	Character Drivers	Graphic (Dot Matrix) Drivers
Features: • Max multiplex rate 1:16 (generally 1:4) • Wide range of segment outputs • RAM and auto-incremental addressing • Low power consumption • No external component • Wide power supply range • Internal LCD bias voltage generation with voltage follower buffers • Internal oscillator, external clock also possible	**Features:** • Multiplex rate up to 1:18 • On-chip character generator • 5x7 character + cursor; 5x8 for Kana (Japanese) & user-defined symbols • On-chip temperature compensation • On-chip character ROM and RAM • Low power consumption • Minimum external components • On-chip LCD bias voltage generation • Internal oscillator / external clock	**Features:** • Wide range of mux rates to optimize power and display size (S/W selectable) • On-chip generation of LCD bias voltages • Low number of external components • Low power consumption • Temperature compensation

LCD Drivers: Key Products

Segment Drivers	Character Drivers	Graphic (Dot Matrix) Drivers

Segment Drivers

- **PCF8566**   4 x 24 Segments
- **PCF85162**   4 x 32 Segments
- **PCF85176**   4 x 40 Segments
- **PCF85134**   4 x 60 Segments
- **PCF85133**   4 x 80 Segments
- **PCF85132**   4 x 160 Segments
- **PCF8536**   8 x 40 Segs + 6PWM
- **PCF8537**   8 x 44 Segments
- **PCA9620**   8 x 60 Segments
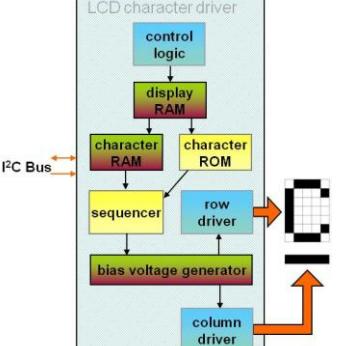
Character Drivers

- **PCF2113**   2-Line x 12-Character Plus 120 icons

- **PCF2116**   4-Line x 12-Character or 2-Line x 24-Character

- **PCF2119**   2-Line x 16-Character Plus160 icons

Graphic (Dot Matrix) Drivers
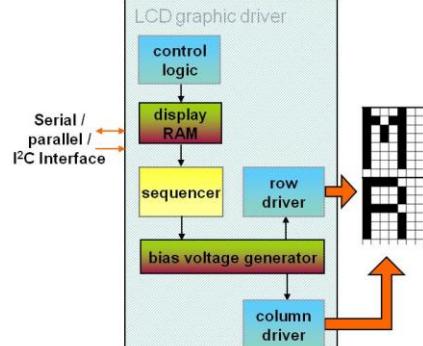
- **PCF8531**   34 x 128 Small 4-x-20 Text Characters Full Graphics

- **PCF8811**   80 x 128 Large Universal Display

- **PCF8578**   8 x 32 (stand-alone) Up to 40,960 dots when combined with 32 **PCF8579**

For Details, see the LCD Drivers Selection Guide

PCₐᶠ8536: 320-Segment Driver

▸ Key Features:
  – I²C-bus (PCx8536AT) or SPI-bus (PCx8536BT) interface
  – Interfaces directly to the LCD cells; driving signals are internally generated
  – 40-Segment and 8-Backplane outputs for driving up to 320 Segments in a 1:8 multiplex rate
  – Supports mux rates of 1:4, 1:6, and 1:8
  – 7-Bit PWM outputs for controlling up to 6 LED's in conjunction with external transistors
  – Configurable backplane outputs; either pinout in the centre of the segment outputs or at the edge of the device
  – Programmable Line Inversion or Frame Inversion
  – Programmable and calibrated Frame Frequency in the range of 60Hz to 300Hz in steps of 10Hz (typical)
  – Wide digital power supply range from 1.8V to 5.5V
  – Wide VLCD range from 2.5V to 6.5V (**9.0V**) when using an external supply
  – Extended operating temperature range up to +85 °C (**+95 °C**)
  – **AEC-Q100 automotive compliant qualification for high robustness and reliability**
  – Available in TSSOP56 Package

▸ Benefits:
  – Designed for horizontal or vertical mounting

▸ Applications:
  – Industrial Control
  – White Goods
  – Smart Meters

Mux	# Display Segments	
	w/o PWM	**w/ 6x PWM**
1:4	**176**	**152**
1:6	**252**	**216**
1:8	**320**	**272**

NXP
PCA8536

PCx8536 TSSOP56

I²C/SPI Bus

control logic

RAM

sequencer

backplane driver — 8

bias voltage generator

PWM Controller → segment driver — 40
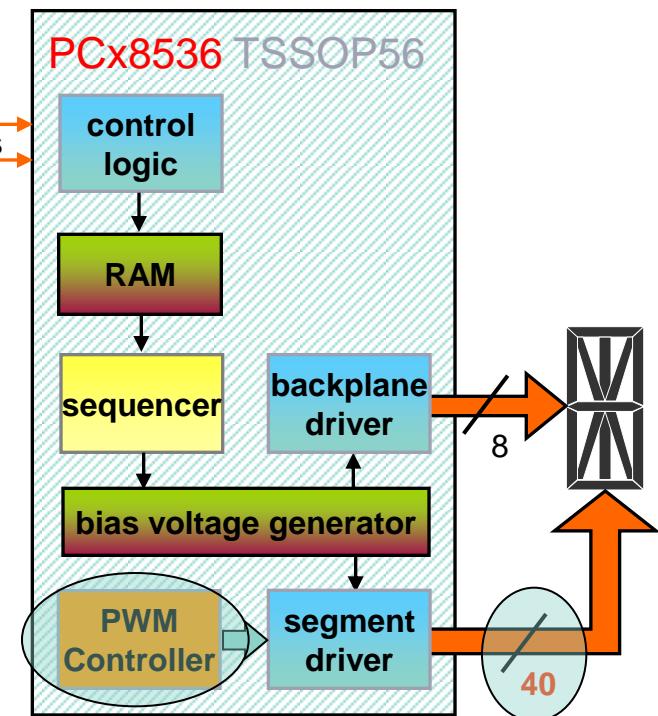
PCA9620: 60 x 8 LCD Driver with I^{2}C-Bus Interface

▸ **Key features and benefits**
  – 480 Segment Drive in Mux 1:8 Mode
  – I^{2}C Interface
  – Integrated charge pump
  – Integrated temperature sensor
  – On-chip VLCD generation
  – Temperature compensated VLCD voltage
  – **Programmable and calibrated frame frequency**
  – Extended frame frequency from 60Hz up to 300Hz; in 10-Hz steps
  – Extended temperature range up to **+105°C**
  – *AEC-Q100 automotive compliant qualification for highest robustness and reliability*

▸ **Potential applications**
  – Applications Requiring High Contrast

▸ **Product characteristics**
  – Wide digital and analog power supply ranges from 2.5V to 5.5V
  – Extended VLCD range from 2.5V to **9.0V**
  – Wide frame frequency range 60Hz to 300Hz
  – Wide operating temp range -40 to **+105°C**
  – 12 x 12 x 1.4 mm LQFP80 package

Black Nematic:
VLCD=7.0V, fF=200Hz
Twisted Nematic:
VLCD=7.0V, fF=100Hz
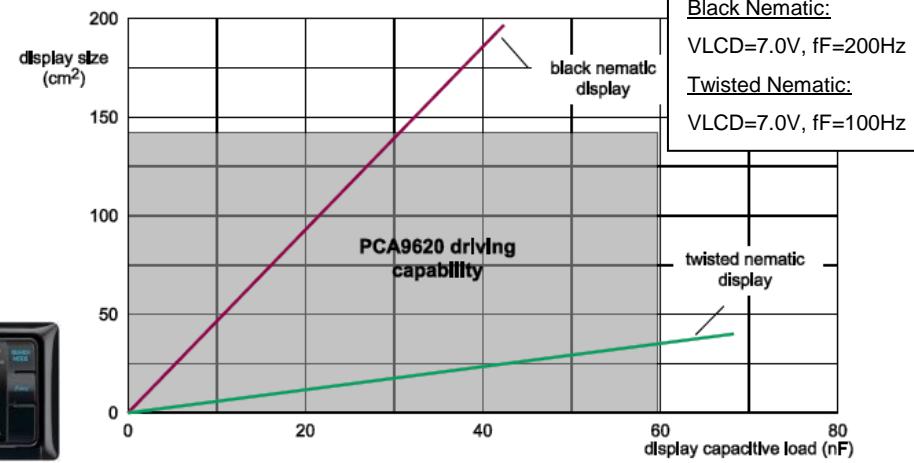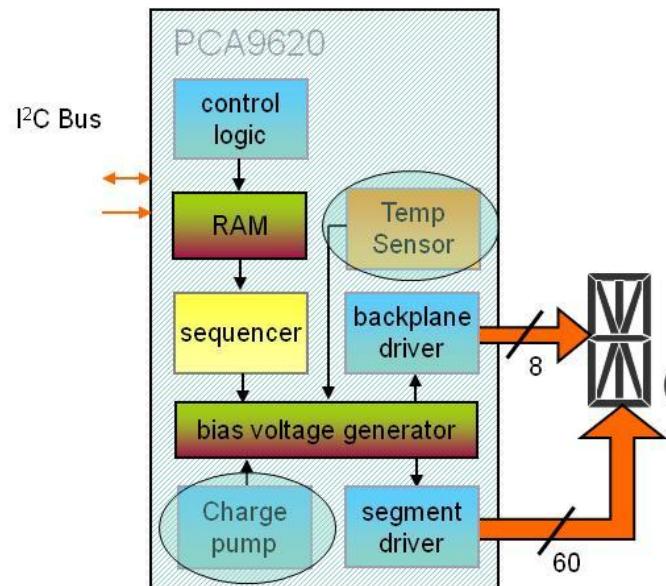
PC$_A^F$8537: 352 Segments or dots LCD Driver

▸ Key Features:
- I²C-bus (PCx8537AH) or SPI-bus (PCx8537BH) interface
- Interfaces directly to the LCD cells; driving signals are internally generated
- 44-Segment and 8-Backplane outputs for driving up to 352 Segments in a 1:8 multiplex rate
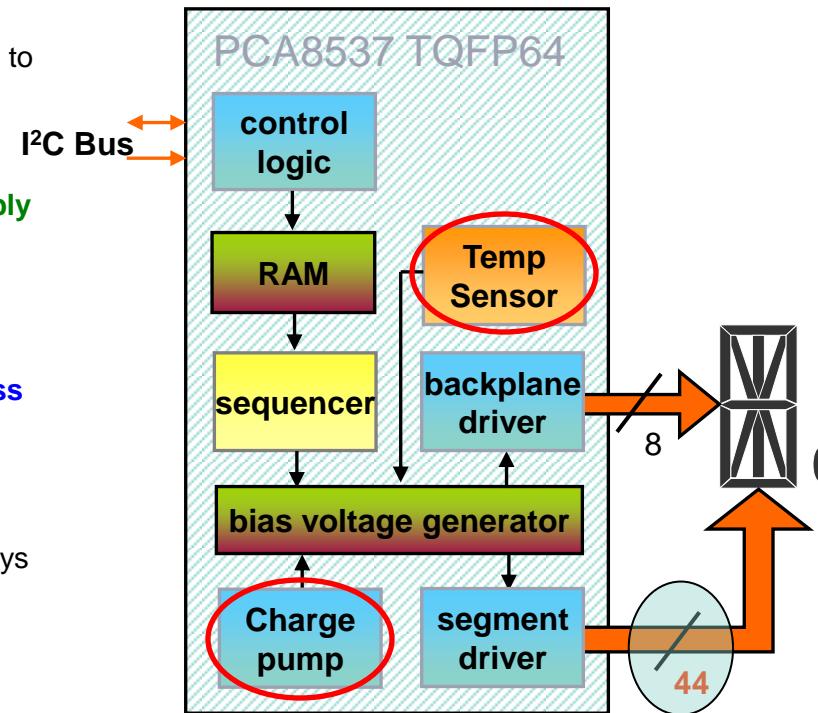- Supports mux rates of 1:1, 1:2, 1:4, 1:6, and 1:8
- Programmable Line Inversion or Frame Inversion
- Programmable and calibrated Frame Frequency in the range of 60Hz to 300Hz in steps of 10Hz (typical)
- Wide digital power supply range from 1.8V to 5.5V
- Wide analog power supply range from 2.5V to 5.5V
- **Wide VLCD range from 2.5V to 9.0V when using an external supply**
- **On-chip charge pump with integrated capacitors**
- **Integrated temperature sensor (readout possible)**
- **Temperature compensated VLCD voltage**
- Extended operating temperature range up to +85 ˚C (**+95 ˚C**)
- **AEC-Q100 automotive compliant qualification for high robustness and reliability**
- Available in TQFP64 Package

▸ Benefits:
- Specifically Designed for high-contrast Vertical Alignment (VA) displays

▸ Applications:
- Industrial Control
- White Goods
- Smart Meters

PCA8537 TQFP64

I²C Bus → control logic

RAM

Temp Sensor

sequencer

backplane driver — 8

bias voltage generator

Charge pump

segment driver — 44

LCD Drivers Demo Boards

▶ **PCA9620 Demo board:**

    ▶ 60 x 8 LCD segment driver in LQFP80 pkg for automotive and industrial applications

▶ **PCA8538 COG Demo board:**

    ▶ Chip-On-Glass 102 x 9 LCD segment driver for automotive and industrial applications

Segment Display Touch Panel Demonstrator

Key Features:

▸ Stand-alone demonstration kit showcases NXP's Capacitive Sensor Technology

▸ Segment display is driven by one PCF85176 (4x40) Segment Driver

▸ Touches are detected by one PCF8885 (8-CH) Capacitive Sensor

▸ High-contrast is attained with vertical alignment (VA) display with 16 touch buttons on-cell

Polarizer

ITO Touch Layer + Glass

ITO Layer (Electrode)
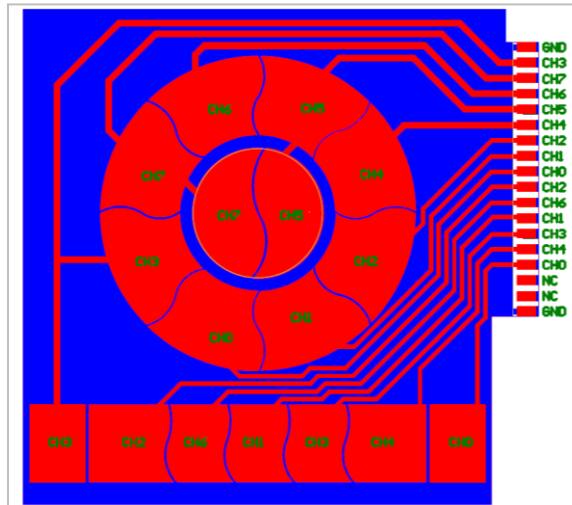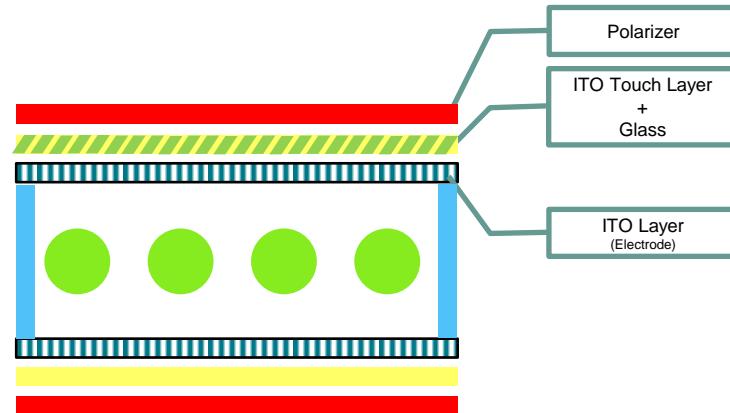
Bus Buffers & Voltage Translators

I^{2}C-Bus Buffer Family

Repeaters		Hot-Swap Buffers	Extenders (Long Cable) (Long Cable Drivers)

Repeaters

PCA9509 — Processor to SMBus — SO	PCA9515/15A/16A — SO
PCA9509A — Processor to SMBus — SO	PCA9518A — 5-Channel Hub Expander — SO
PCA9509P — Processor to SMBus — SO	PCA9519 — 4 x PCA9509 — SO
PCA9517A — 0.9 – to 5.5V — SO	PCA9525 — 3-mA Drive — NO
PCA9507 — RTA for HDMI — SO	PCA9605 — 30-mA Drive — NO
PCA9527 — PCA9507 + ½ PCA9517 — SO	PCA9646 — 30-mA Drive; 1:4-Channel — NO
PCA9617A — 0.8 to 5.5V — SO	PCA9521 [1] — PCA9522 wo/HS — IO

Hot-Swap Buffers

PCA9522 [2] — IO
PCA9508 — Active Level Shifter — SO
PCA9512A/12B — Active Level Shifter — IO
PCA9511A — 0.6-V Threshold — IO
PCA9514A — 0.8-V Threshold — IO
PCA9513A — 92-μA Current Source — IO
PCA9510A — No Accelerator — IO

Extenders (Long Cable) (Long Cable Drivers)

P82B96 [3] — SO
P82B715 — No Static Offset — AM
PCA9600/9601 — 1-MHz Speed — SO

[1] Devices in development
[2] PCA9522 is compliant for ATCA applications
[3] P82B96 is widely used for opto-isolation applications
Blue ➔ 1 MHz system

NO = No Offset
SO = Static Offset
IO = Incremental Offset
AM = Amplifier

38

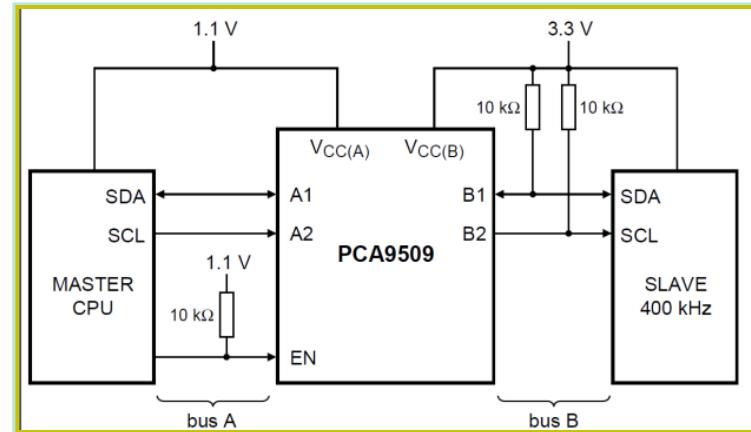# Static-Offset Bus Repeater Value Proposition

▸ **Why used?**
  – Voltage level shifting between host processor's I2C-bus and peripheral devices when there is a mismatch of supply voltages
  – Used when additional drive is needed or to <u>isolate</u> two sections of the bus loading

▸ **Where used?**
  – Digital logic level translation between host processor and slave device where **capacitance isolation and speed of >3MHz (up to 30MHz) is required**

▸ **NXP Level Shifter Portfolio**

Device	Description	Normal I/O	Static Level Offset I/O	Accelerator	Idle Stop Detect for Hotswap	Interrupt	ESD (HBM)
PCA9508	0.9V-to-5.5V Level Shifter with Offset Free Hot-Swap	A Side	B Side		×		6KV
PCA9509	1.0V-to-5.5V Level Shifter	B Side	A Side				2KV
PCA9515A	3.3V / 5.0V I2C-Bus Repeater		A & B Sides				2KV
PCA9516A	5-Channel I2C Bus Hub		A & B Sides				2KV
PCA9517A	0.9V-to-5.5V Level Shifter	A Side	B Side				5KV
PCA9617	0.8V-to-5.5V Level Shifter	A Side	B Side				5KV
PCA9518A	5-Channel I2C Bus Hub Expander		A & B Sides				2KV
PCA9519	1.1V-to-5.5V Quad Level Shifter	B Side	A Side				2KV

# PCA9525, PCA9605 & PCA9646: No Offset I²C-Bus Buffer

Features

▸ Extends bus load limit by buffering both SCL & SDA lines

▸ Uses a "scoreboard" technique to determine direction

▸ "Regenerating" and bi-directional SDA buffers

▸ "Regenerating", but uni-directional SCL buffers

▸ Imposes minimal system design restrictions

▸ Ability to drive large buses and long cables

▸ Does not support clock stretching

▸ Differences:

   – PCA9525 supports 1MHz I²C Fast-mode (3 mA) and SMBus (4 mA)

   – PCA9605 supports Fast-mode Plus (30 mA)

   – PCA9646 supports Fast-mode Plus (30mA) and may be used to fan-out the bus (1:4 channels)
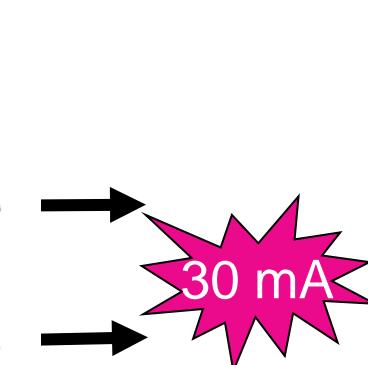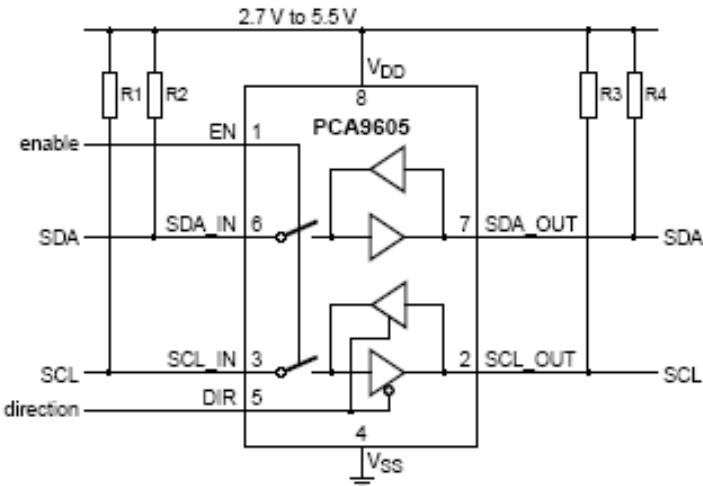
Applications

▸ Re-driving of the I²C-bus with standard logic levels

▸ Regenerating standard logic levels on the bus

40
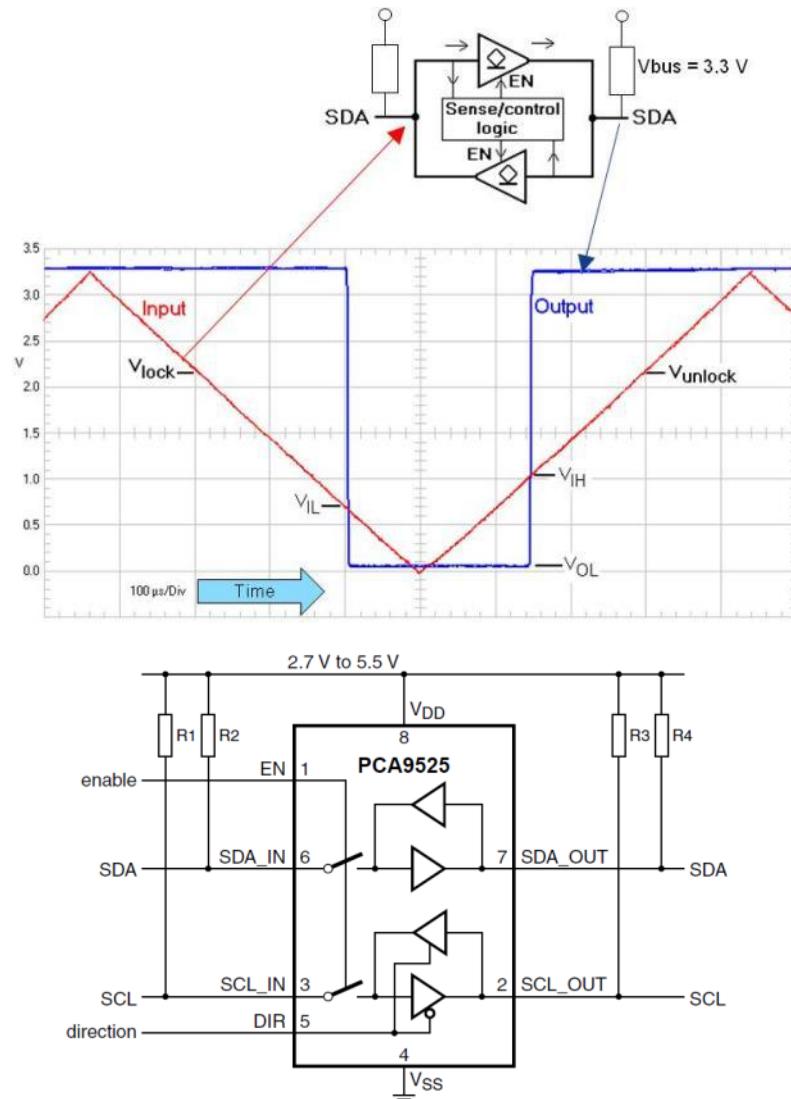
PCA9605: Fm+ I²C No Offset Bus-Buffer

1 MHz I²C-
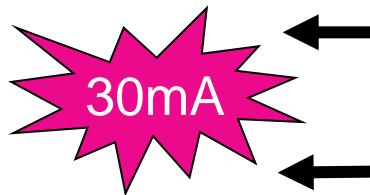
FEATURES
- Bi-directional data transfer with unidirectional clock (direction pin)
- Scoreboard method provides for normal voltage levels on both sides of the device
- 30 mA sink capability for interfacing between Fm+ bus master and slaves

KEY POINTS
- Longer point-to-point or multi-point architectures
- Isolates capacitance allowing 4000 pF on both sides of the bus (540 pF @ 1 MHz)
- Normal interface works with any other device

	Voltage Range	Temp. Range	Bus Voltage Range
PCA9605	2.7V - 5.5V	-40 °C to +85 °C	2.7V - 5.5 V

Incremental I²C-Bus Buffers
PCA9521 & PCA9522

Features

▸ "Regenerating" bi-directional SDA and SCL buffers with 1.8 – 10V bus range (device supply 2.7 – 5.5V) that can be used in series

▸ Impose minimal system design restrictions

▸ No rise time accelerators which might cause glitch

▸ Supports 1MHz I2C Fast-mode (6mA)

Applications

▸ Multiple bus buffers needed for capacitance isolation and to buffer the I2C signals from board to board with connectors.

▸ Voltage level translation between a 1.8V or 2.5V bus and a 3.3V or 5V bus.

▸ When the system is fully loaded, some of the buffers are connected **in series** and the architecture is such that static offset bus buffers can't be used

▸ The clock signal has to be bidirectional, so no offset bus buffers can't be used.

002aaf280

002aaf318
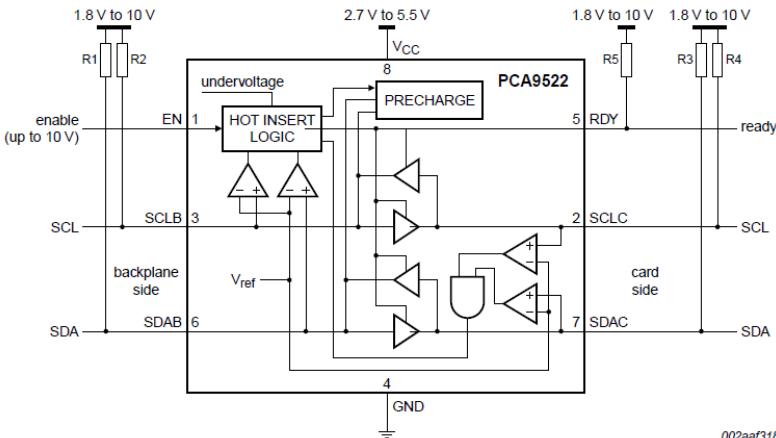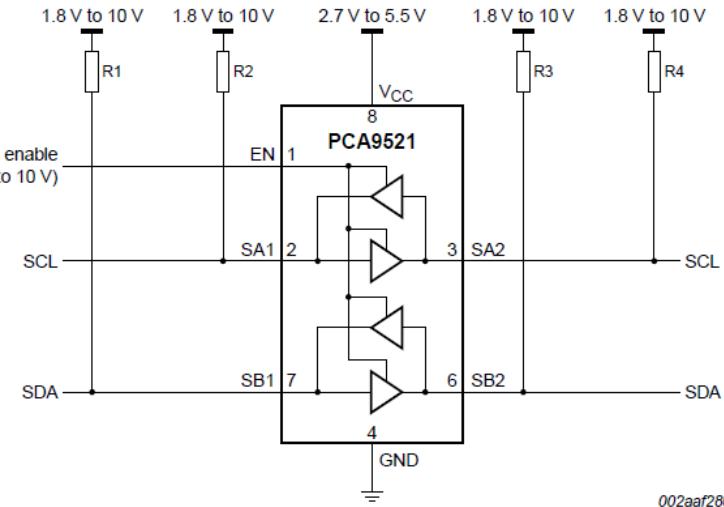
Long-Distance Bus Buffers Value Proposition

‣ **Why used?**
  – Drives the I^{2}C-bus signals over a long-distance cable and through inter-connects
  – Re-drive the SCL and SDA signals into loads exceeding the maximum specified 400-pF bus capacitance

‣ **Where used?**
  – Between card interconnects (does not support voltage level translation)
  – In noisy environment with compressors, pumps, relays, EMI, etc.
  – To eliminate the need for multiple costly bus controllers
  – Opto-Couplers Interface

‣ **Why NXP Long-Distance Buffers?**
  – Large selection of buffers
  – Continuous innovation with new differential I^{2}C buffers (P82B48x) for very rugged environments
  – Invented the I^{2}C-bus

‣ **NXP Long-Distance I^{2}C-Bus Buffer Portfolio**

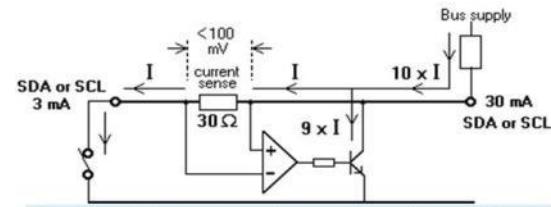| Device	V_{CC}	F_{MAX}	Max Cable-Side Load	Cable Length	Capacitance Isolation	Interrupt	Signal Levels	ESD (HBM)
P82B715	3.0V – 12.5V	100kHz	3,000pF	50m			Single-ended	2.5KV
P82B96	2.0V – 15.0V	400kHz	4,000pF	20m	×		Single-ended	3.5KV
PCA9600/01	2.5V – 15.0V	1MHz	4,000pF	20m	×		Single-ended	4.5KV
PCA9605	2.7V – 5.5V	1MHz			×		Single-ended	2.5KV

[1] In Development

P82B715: I^{2}C-Bus Extender

Features

▸ Wide supply voltage range from 3V to 12V

▸ Amplifies the bus drive current in one direction

▸ Scales the current drive by 10x, but does not isolate the bus

▸ Scales the capacitive loading and is capable of driving 4000pF load

▸ Inputs have no switching level thresholds

▸ Compatible with I^{2}C-bus, SMBus, and PMBus

▸ Does not do voltage level shifting

Applications

▸ Driving a bus with low pull-up resistors

▸ Extending the communication distance of the I^{2}C-bus over wire

The driver for the bus at the left side only needs to sink 1/10 of the 30 mA current in the pull-up resistor of the bus on the right.
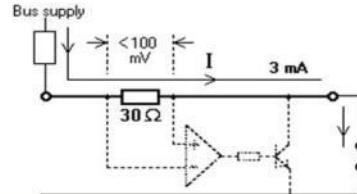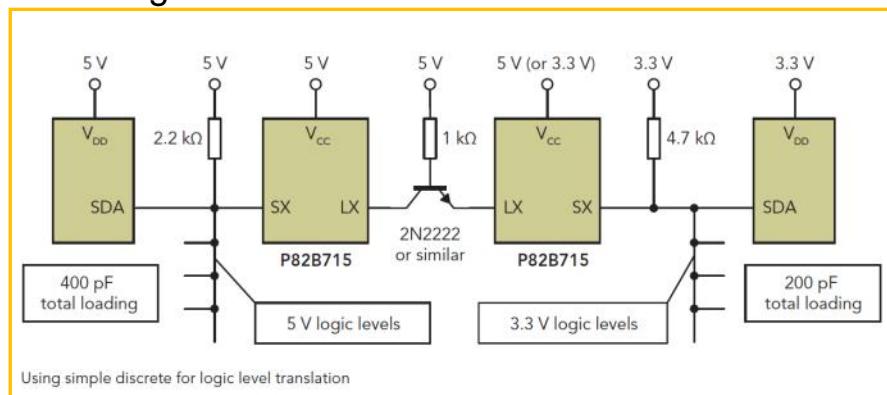
The driver for the bus at the right side needs to sink all of the 3 mA current in the pull-up resistor of the bus on the left.
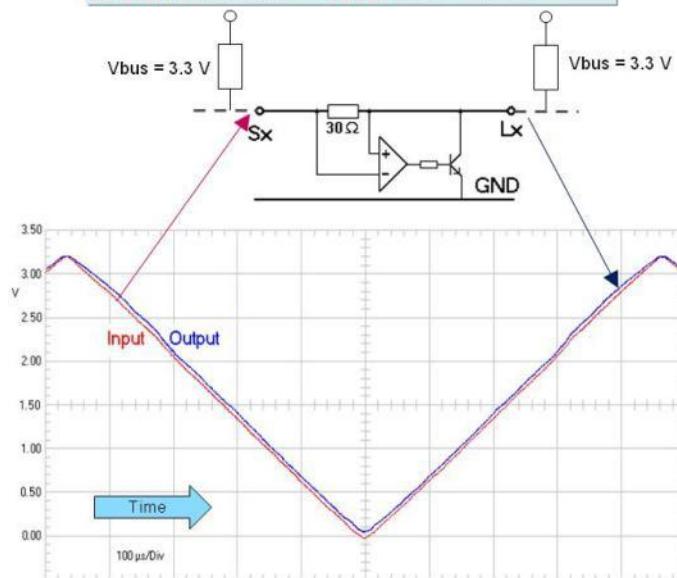
Note how the two I/Os are internally connected by a 30 ohm resistor. For all input voltages, the voltage difference between I/Os never exceeds 100 mV.

Using simple discrete for logic level translation

Voltage-Level Translator Family

Active Level Shifter
- input & Output dual supply
- Capacitance Isolation
- High Noise Margins

PCA9509/A/P — Processor to SMBus	**SO**
PCA9507 — RTA for HDMI	**SO**
PCA9517A — 0.9 – to 5.5V	**SO**
PCA9527 — PCA9507 + ½ PCA9517	**SO**
PCA9508 — Active Level Shifter	**SO**
PCA9512A/12B — Active Level Shifter	**IO**
PCA9519 — 4 x PCA9509	**SO**
PCA9617A — 0.8 to 5.5V	**SO**

Active level Shifter
- Single Supply
- Capacitance Isolation

P82B96 — 2.2 – 15V	**SO**
PCA9518A — 2.3 – 5.5V	**AM**
PCA9600/9601 — 2.2 – 15V	**SO**
PCA9515/15A/16A — 2.3 – 5.5V	**SO**

Passive Level Shifter
- No capacitance Isolation
- Low Power & Low Cost

PCA9306 — 1 – 5.5V	**NO**
GTL2002/03/10/00 — 1 – 5.5V	**NO**
NVT20xx — 1 – 5.5V w low Ron	**NO**

NO = No Offset

SO = Static Offset

IO = Incremental Offset

AM = Amplifier

Blue ➜ 1 MHz system

Active Level-Shifter Value Proposition

▸ **Why used?**
  - Voltage level shifting between host processor's I^{2}C-bus and peripheral devices when there is a mismatch of supply voltages
  - Used when additional drive is needed or to <u>isolate</u> two sections of the bus loading

▸ **Where used?**
  - Digital logic level translation between host processor and slave device where **capacitance isolation and speed of >3MHz (up to 30MHz) is required**

▸ **Why NXP Level-Shifter?**
  - Largest selection of active and passive level shifters
  - Continuous innovation with new NXP voltage follower and zero-offset active buffers

Device	Description	Normal I/O	Static Level Offset I/O	Accelerator	Idle Stop Detect for Hotswap	Interrupt	ESD (HBM)
PCA9508	0.9V-to-5.5V Level Shifter with Offset Free Hot-Swap	A Side	B Side		×		6KV
PCA9509	1.0V-to-5.5V Level Shifter	B Side	A Side				2KV
PCA9515A	3.3V / 5.0V I^{2}C-Bus Repeater		A & B Sides				2KV
PCA9516A	5-Channel I^{2}C Bus Hub		A & B Sides				2KV
PCA9517A	0.9V-to-5.5V Level Shifter	A Side	B Side				5KV
PCA9617	0.8V-to-5.5V Level Shifter	A Side	B Side				5KV
PCA9518A	5-Channel I^{2}C Bus Hub Expander		A & B Sides				2KV
PCA9519	1.1V-to-5.5V Quad Level Shifter	B Side	A Side				2KV
PCA9527	3.0V-to-5.5V Level Shifter	A Side	B Side	× (A-Side)		×	8KV

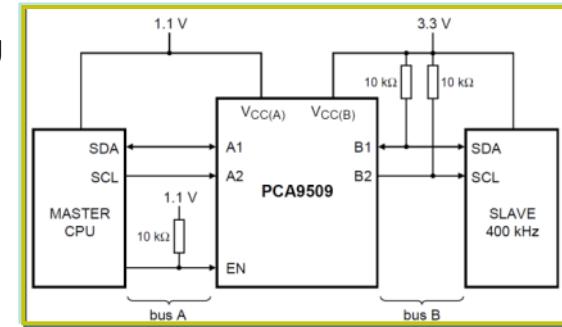# Passive Level-Shifter Value Proposition

▶ **Why used?**
  – Voltage level shifting between host processor's I^{2}C-bus peripheral devices when there is a mismatch of supply voltages
  – Used when additional drive is <u>not</u> needed and capacitive loading is <u>not</u> an issue

▶ **Where used?**
  – Digital logic level translation between host processor and slave device; **no direction control, speed of <3MHz and no capacitance isolation are required**
  – Applications requiring open-drain bidirectional or unidirectional voltage translation (down to 1V) without a direction pin

▶ **Why NXP Passive Level-Shifter?**
  – Largest selection of active and passive level shifters
  – Continuous innovation with new NXP Voltage Translation family (NVT20xx) in widths of **1, 2, 3, 4, 6, 8 and 10 bits**

▶ **NXP Passive Level-Shifter Portfolio**

Device	Description	R_{ON}	Process	ESD (HBM)
PCA9306	2-Bit Bidirectional Voltage-Level Translator	3.5 Ω	CMOS	2kV
GTL2002	2-Bit Bidirectional Voltage-Level Translator	6.5 Ω	BiCMOS	>2kV
GTL2003	8-Bit Bidirectional Voltage-Level Translator	6.5 Ω	BiCMOS	>2kV
GTL2010	10-Bit Bidirectional Voltage-Level Translator	6.5 Ω	BiCMOS	>2kV
GTL2000	22-Bit Bidirectional Voltage-Level Translator	6.5 Ω	BiCMOS	>2kV
NVT2001/02/03/04/06/08/10	x-Bit Bidirectional Voltage-Level Translator	3.5 Ω	BiCMOS	>4kV

PCA9306
Bidirectional I²C-Bus & SMBus Level Translator

Features

▸ Bi-directional without need for direction pin

▸ Voltage translation between any voltage from 1.0 V to 5.5 V

▸ Lock-up free operation for isolation when EN = LOW

▸ Mixed-mode I²C-bus application: run two buses, one at 400 kHz other at 100 kHz operating frequency

▸ Excellent ESD performance

Applications

▸ Voltage Level Translation
  – Mixed-mode I²C-Bus Applications
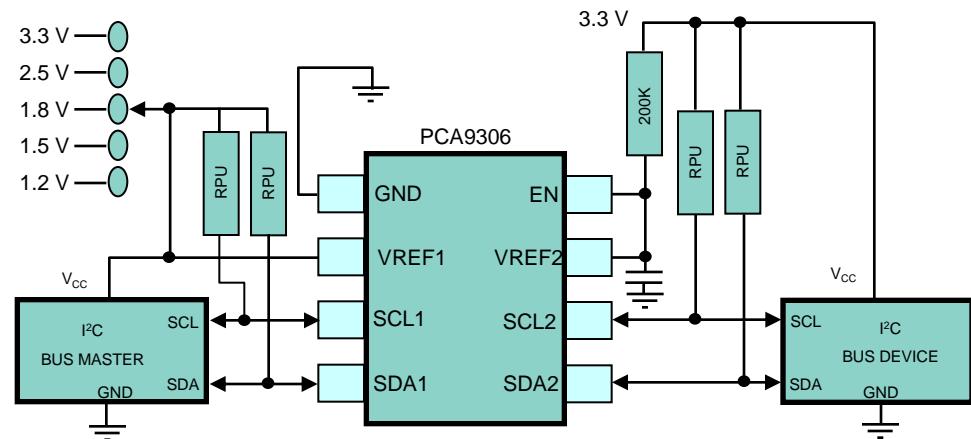
NVT20xx: Level Translator Family

- ▸ **Where used?**
  - – Digital Logic level translation
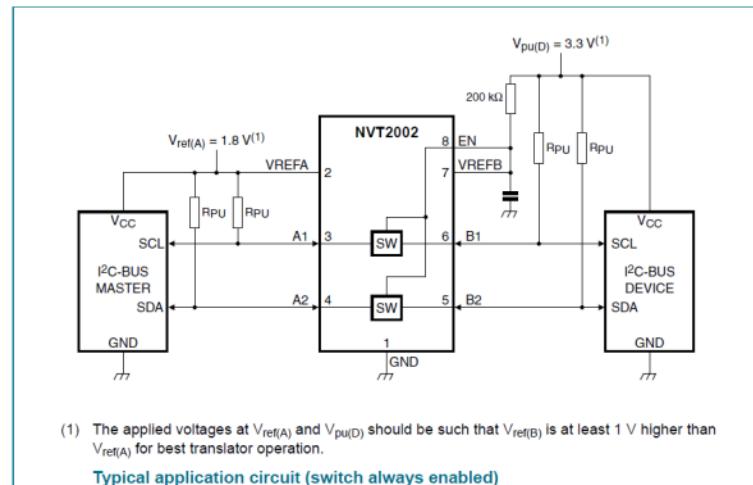 - – TI's PCA9306 is drop-in replacement for NXP GTL2002 and PCA9306

- ▸ **Why used?**
  - – Voltage level shifting in range of 1V and 5V
  - – Bi-directional without direction pin

- ▸ **Why NXP NVT 20xx Level Shifter?**
  - – More consistent device naming - NVT means "NXP Voltage Translator"
    - o NVT2001 – 1-bit
    - o NVT2002 – 2-bit   (alt source GTL2002)
    - o NVT2003 - 3-bit
    - o NVT2004 – 4-bit
    - o NVT2006 – 6-bit
    - o NVT2008 – 8-bit   (alt source GTL2003)
    - o NVT2010 – 10-bit   (alt source GTL2010)
  - – In TSSOP and smaller packages
  - – Can be used as FET replacement
  - – Continuous innovation from NXP

# CH	New	OLD	Usage
1	NVT2001	--	Clock
2	NVT2002 PCA9306	GTL2002	I^{2}C
3	NVT2003*	--	I^{2}C, server
4	NVT2004*	--	SPI
6	NVT2006	--	
8	NVT2008	GTL2003	Digital RGB
10	NVT2010	GTL2010	Data Bus
22	--	GTL2000	

* sampling

(1) The applied voltages at $V_{ref(A)}$ and $V_{pu(D)}$ should be such that $V_{ref(B)}$ is at least 1 V higher than $V_{ref(A)}$ for best translator operation.

Typical application circuit (switch always enabled)

General Purpose I/O Expanders

GPIO Expander Value Proposition

▸ **Why used?**
  – Easily adds I/O via I^{2}C-bus
  – Additional inputs for keypad, switch, signal monitoring and fan control
 – Additional outputs for LED control, ACPI power switch, relay, timers and sensor.

▸ **Where used?**
  – HVAC Controllers
  – Building Intrusion Systems
  – Industrial Controls
  – Energy Management Systems
  – Test and Measurement Instrumentations

▸ **Why NXP GPIOs?**
  – Largest selection of 4, 8, 16 and 40-bit GPIO in Quasi-bidirectional and Push-pull outputs with Interrupt and/or reset in a wide range of packages
  – Invented the I^{2}C-bus. Continuously developing newer devices with added features to support different applications.

Microcontroller

Keypad Control

2-wire

GPIO

Zoom-in view
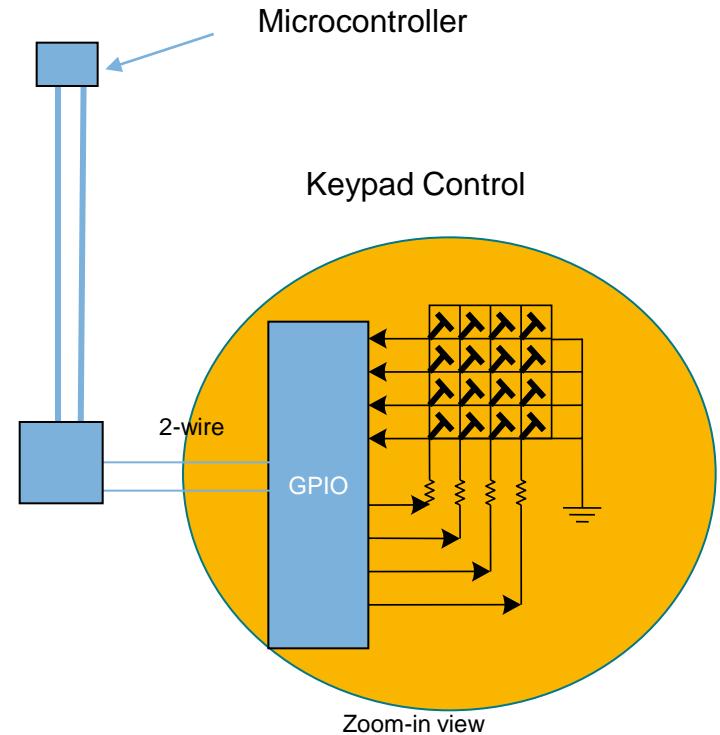
I/O Expanders with Flexible Output Structures

Quasi-Output Structure:

- Strong PMOS transistor is turned on only during the LH transition and turned off during static drive

- Weak pull-up current source (100µA) at the output

- Used in low-power applications where the 100-µA drive is sufficient to bias the inputs of CMOS devices

- May be reconfigured as an input or output without the need of a port configuration register

Totem-Pole Output Structure:

- Upper PMOS transistor is turned on during LH transition and static high drive. Up to 10mA (or 25mA) of high drive

- Some devices have weak pull-up resistors at the output

- Used in applications requiring high drive for heavy loads

- Extra command byte needed to switch an I/O pin between input and output

General Purpose I/O
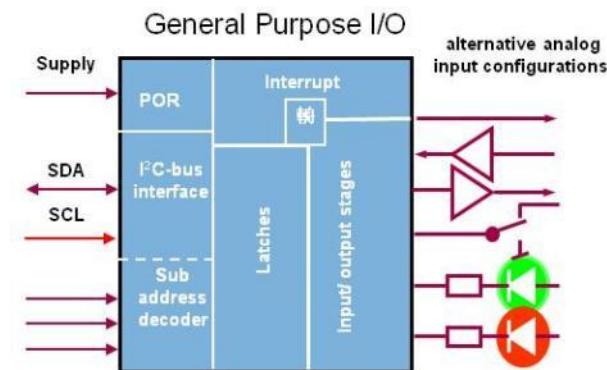
Quasi-Output I²C I/O Expanders

Device	Number of I/O's	Features			
		RESET	INTERUPT	EEPROM	I/O Pull-Up [1]
PCF8574(A)	8		×		Weak PU
PCA8574(A)	8		×		Weak PU
PCA9500	8			2 Kbit	Weak PU
PCA9501	8		×	2 Kbit	Weak PU
PCA9558 [2]	8			2 Kbit	Weak PU
PCA9670	8	×			Weak PU
PCA9672	8	×	×		Weak PU
PCA9674 (A)	8		×		Weak PU
PCF8575	16		×		Weak PU
PCF8575C	16		×		Open Drain
PCA8575	16		×		Weak PU
PCA9671	16	×			Weak PU
PCA9673	16	×	×		Weak PU
PCA9675	16		×		Weak PU

Note [1]: The Quasi-outputs have a strong pull-up (transistor) to V_{DD} to allow fast rising edges into heavy loaded outputs. The devices with weak pull-ups have a 100-μA current source to V_{DD}.

Note [2]: With 5-Bit Mux, 1-Bit Latch Dip Switch

Totem-Pole Output I/O Expanders

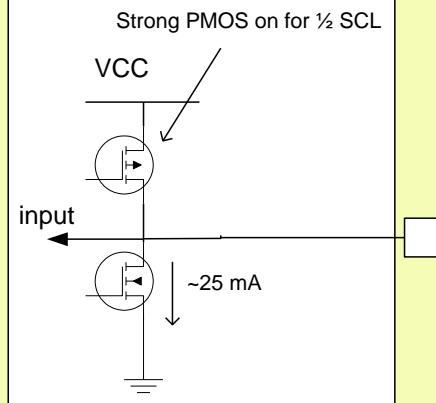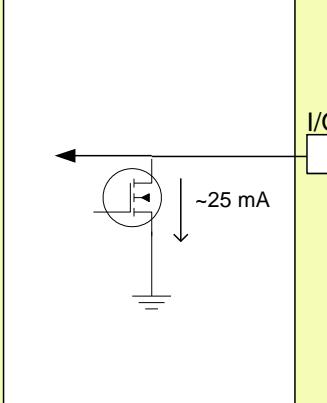| Device	Number of I/O's	Features			
		RESET	INTERUPT	Other	I/O Pull-Up
PCA9536	4				100KΩ
PCA9537	4	×	×		
PCA9502	8	×	×	SPI + I^{2}C	
PCA9534	8		×		
PCA9538	8	×	×		
PCA9554 (A)	8		×		100KΩ
PCA9557	8	×			100KΩ
PCA9574	8	×	Maskable	OD or PP, LV	Prog. PU / PD
PCA9535	16		×		
PCA9535C	16		×		Open Drain
PCA9539 (R)	16	×	×		
PCA9555	16		×		100KΩ
PCA9575	16	×	Maskable	OD or PP, LV	Prog. PU / PD
PCA9505	40	×	×		100KΩ
PCA9506	40	×	×	OE	
PCA9698	40	×	×	OD or PP, OE	

Open-Drain Output I²C I/O Expanders

‣ **Devices**
  – The **PCF8575C** and **PCA9535C** are 16-bit GPIO Expanders with open drain outputs.
  – Some push-pull GPIO Expanders' outputs can be configured to turn off the upper PMOS transistor and used as open-drain devices
    – The **PCA9574** is an 8-bit GPIO Expander
    – The **PCA9575** is a 16-bit GPIO Expander
   – The **PCA9698** is a 40-bit GPIO Expander

‣ **Features**
  – The **PCF8575C** has a strong PMOS pull-up transistor to pull the signal from low to high, when the device is driving as an output.
  – The **PCA9535C** has true open-drain output structure.
  – Both devices have open-drain interrupt output.

‣ **Applications**
  – The open-drain output GPIO Expanders are suited for applications requiring the expanders to put the I/O in high-impedance state and safe in power consumption.

PCF8575C Output Structure	PCA9535C Output Structure
Strong PMOS on for ½ SCL VCC input ~25 mA	I/O ~25 mA
• Strong PMOS transistor is turned on only during the LH transition • PMOS transistor is off during static drive	• No upper PMOS transistor • No pull-up resistor • No weak current drive

GPIO Expanders Applications: PCA9698 Example
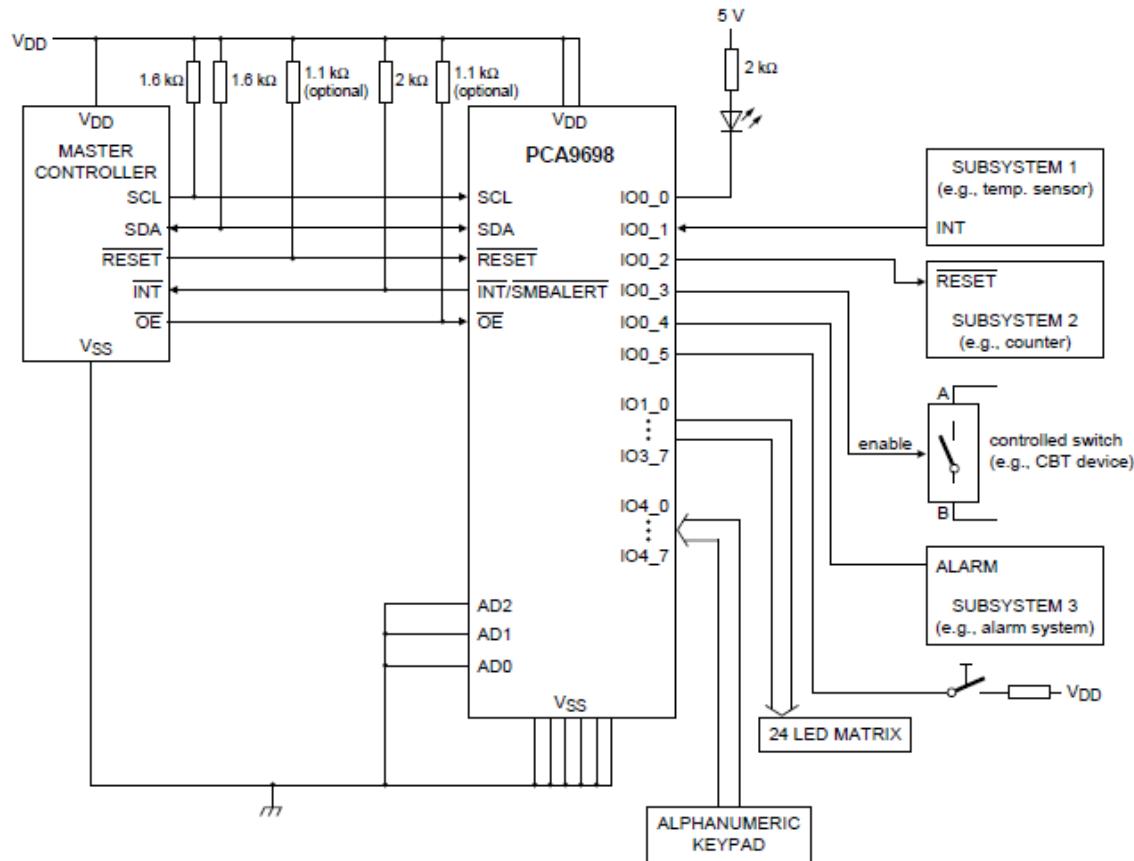
Device address configured as '0010 000x' for this example.
IO0_0, IO0_2, IO0_3, IO1_0 to IO3_7 are configured as outputs.
IO0_1, IO0_4, IO4_0 to IO4_7 are configured as inputs.

▸**I^2C-bus Serial Interface**
– Fast-mode Plus (1MHz)
– Supports up to 64 devices on same bus

▸**Control Inputs and Outputs**
– Reset
– Interrupt (maskable)
– OE

▸**Configurable Outputs**
– Push-pulls
– Open-drain

▸**Wide Applications**
– Driving individual LEDs
– Driving LED matrix
– Reading from Keypad
– Subsystem control signals
– Subsystem status signals
– Live Insertion (I_{OFF}) Supports

Low-Voltage GPIO Expanders

Features:

- Operates from 1.65V to 5.5V; designated by "A" at the end of the part number, e.g. PCA9555**A**
- Drop-in replacement for previous GPIO Expanders which operates from 2.3V to 5.5V
- Input latch and other new Agile I/O features, designated by "L" in the middle of the part number, e.g. PCA**L**9555A
- Agile I/O provides the following features:
  - GPIO input latch (bit by bit – default not latched). Locks I/O pin change on input until the register is read.
  - GPIO output drive strength control (bit by bit – default 10 mA). User can program I/O drive strength 2 mA, 4 mA, 8 mA or 10 mA. Could be used to control the brightness of LEDs.
  - GPIO open drain control (24-bit bit by bit and 8 and 16-bit bank by bank – default push pull). Provides an optional open-drain output for each I/O pin.
  - GPIO pull up or pull down (bit by bit – default no PU/PD). User can turn on/off an internal pull-up or pull-down on each I/O pin.
  - GPIO interrupt mask and interrupt status (bit by bit – default not masked). User can enable or disable interrupts of each I/O pin. Identifies the source of interrupts of each I/O pin.
  - 5 state address pins to allow more devices on the bus (24-Bit GPIO Expanders only)
- Dual supply voltages, designated by "64" in the part number, e.g. PCA**64**16A

Feature	Single V_{CC}						Two V_{CC}	
	INT & PU	INT	INT & RST	INT & PU	INT	INT & RST	INT & RST	INT & RST
				Input Latch	Input Latch	Input Latch		Input Latch
8 bit	PCA9554B PCA9554C		PCA9538A	PCAL9554B PCA9554C		PCAL9538A	PCA6408A	PCAL6408A
16 bit	PCA9555A	PCA9535A	PCA9539A	PCAL9555A	PCAL9535A	PCAL9539A	PCA6416A	PCAL6416A
24 bit							PCA6424A	PCAL6424A

Low-Voltage GPIO Expanders – Comparison Table

Feature	PCA9574/75	PCA64XX	PCAL64XX	Comments
Number of I/O's	8 or 16	8 or 16 or 24	8 or 16 or 24	
Serial Interface – 400 kHz	I²C-Bus	I²C-Bus	I²C-Bus	
Number of devices on bus	1, 2 or 16	2, 4 or 8	4, 5 or 8	One address pins provides two addresses except for the PCA9575 which has no address pins on the 24 pin version due to the separate supply per octal but the 28 pin version has four address pins allowing 16 devices on the bus. PCAL6424A have one pin with 5 input states.
Supply Voltage Range at Vcc core and Vcc I/O	1.1 V to 3.6V	1.65 V to 5.5 V	1.65 V to 5.5 V	Supports lower supply voltages with supply per octal for the PCA9574/75 and supply per total I/O for PCA(L)64XX.
Input & Output, Polarity Inversion and Configuration Command Byte	Yes	Yes	Yes	Registers used by all I/O expanders to control/configure I/o pins
Bus-Hold - Programmable	Yes	No	No	Very small current source maintains undriven line high or low, doesn't cause continuous current drain when line is at opposite signal level.
Pull-up / Pull-down - Programmable	Yes	No	Yes	100-kΩ pull-up or pull-down at the I/O's. Provides a valid logic level when the I/O is not actively driven.
Input Latch - Programmable	No	No	Yes	Select which input changes "latch" in interrupt if input changes back before the register is read
Interrupt Mask - Programmable	Yes	No	Yes	Select which input changes would not generate an interrupt to reduce spurious interrupts.
Interrupt Status - Register	Yes	No	Yes	User may read this register to identify the source of an interrupt directly without having to remember the previous state of the input
Open Drain Output - Programmable	No	No	Yes	Select I/O from push pull to open drain per byte (8 or 16-bit) or bit (24-bit)
Output Drive Current - Programmable	No	No	Yes	Selects reduced portion of output to control slew rate
Input Current Limiter	No	No	Yes	Reduces current through the input when input voltage is above the supply voltage
Hardware Reset	Yes	Yes	Yes	External pin resets the state machine and I/O to default if fault
Software Reset	Yes	No	No	User reset the device in software to quickly go to a know state
$I_{standby}$ (V_{DD} = 3.6V)	0.25 μA (Typ.) 1 μA (Max.)	0.1μA (Typ.) 2 μA (Max.)	0.1μA (Typ.) 2 μA (Max.)	Lower standby current (numbers shown are estimates for 24 bit LV GPIO, for 8 & 16 bit1.5uA (typ) 7uA (max)

PCAL6416A: Dual-V_{CC} Low-Voltage, 16-Bit I²C-Bus Expander with /INT, Reset and Configuration Registers

Features:

- Operating Power-Supply Voltage Range of 1.65 V to 5.5 V
- Low Standby Current Consumption of 3 µA (Max)
- Bidirectional Voltage-Level Translation between 1.8V to 5V SCL/SDA and 1.8V to 5V Totem Pole configured I/O Port
- Schmitt-Trigger Hysteresis; 10% of I²C-Bus Supply Voltage
- Fast Mode I²C-Bus Operating Frequency of up to 400-kHz
- Active-Low Reset Input
- Open-Drain Active-Low Interrupt Output
- 5-V Tolerant I/O Ports
- Output port configuration: bank selectable push-pull or open-drain output stages
- Interrupt status (read-only) register identifies interrupt source
- Bit-wise I/O programming for output drive strength, input latch, pull-up/pull-down enable, pull-up/pull-down selection, and interrupt mask
- High current Drive for Directly Driving LEDs
- Internal Power-On Reset
- Power-Up With All Channels Configured as Inputs
- No Glitch On Power-Up
- Package – 24 pin TSSOP, HWQFN and CSP
- Latch-Up Performance Exceeds 100 mA per JESD 78, Class II
- ESD Protection Exceeds JESD 22
  - 2000-V Human-Body Model (A114-A)
  - 1000-V Charged-Device Model (C101)
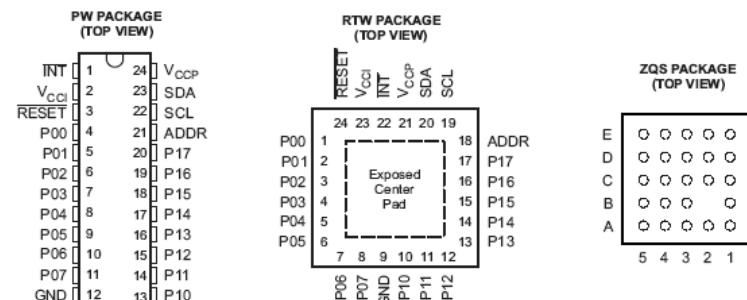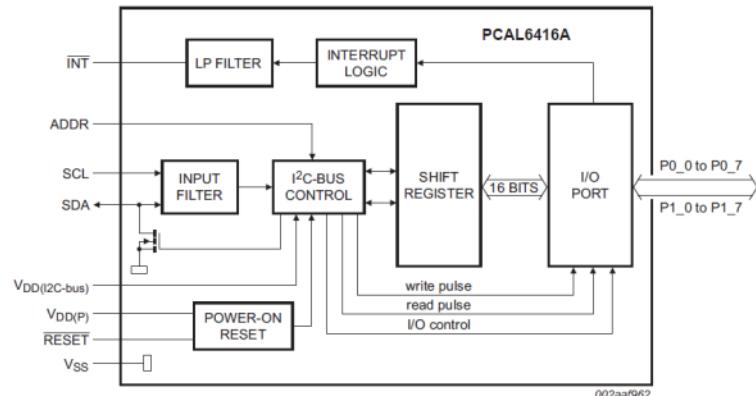
The exposed center pad, if used, must be connected only as a secondary GND or must be left electrically open.

Temperature Sensors

Temperature Sensors Value Proposition

▸ **Where used?**
- Building Thermostats
- Energy Management
- Solar Panel Systems
- Power Receptacles
- Industrial Controllers
- Heating and Cooling Controllers

▸ **Why used?**
- Determine the temperature
- Set window for Interrupt, alarm, fan control, shutdown, etc.

▸ **Why NXP Thermal Sensor?**
- Large selection of commonly used local sensor and local/remote sensor thermal sensors in a wide range of packages
- Continuous innovation with new low price LM75B local sensor in small 2 x 3 mm package

Part #	Accuracy	SMBus Timeout
LM75A / 75B	±2 ˚C	A = No; B = Yes
SE95	±1 ˚C	No
SE98A	±1 ˚C	Yes
SE97B*	±1 ˚C	Yes

local

local   wire   Remote Diode Sensor
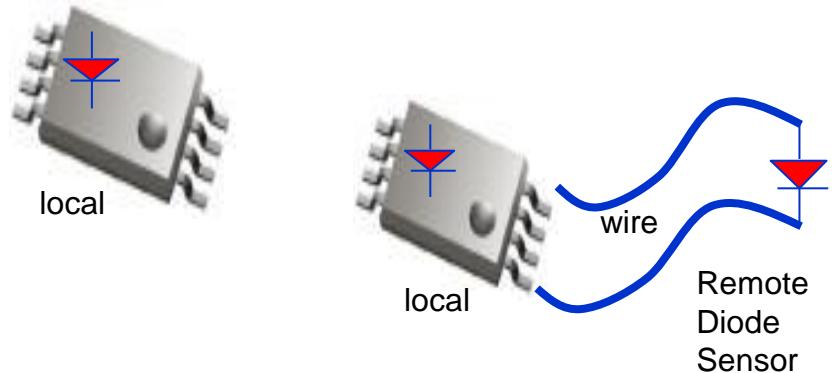
Part #	Local Sensor Accuracy	Remote Sensor Accuracy
NE1617A	±2 ˚C	±3 ˚C
SA56004	±2 ˚C	±1 ˚C

Note: * With 2Kbit EEPROM

Thermal Sensor Portfolio

Accuracy (vertical axis)

±1°C Remote, ±2°C Local, 11-bit ADC

DDR3 SPD, ±1°C, 11-bit ADC, 2K EEPROM

Low Voltage, ±1°C, 11-bit ADC

| SE95 | SE98A | SA56004 | | SE97B |

Improved ±1°C LM75, Local, 11-bit ADC

±3°C Remote, ±2°C Local, 8-bit ADC

| LM75A | | NE1617A | PCT2075 |

±2°C, 11-bit ADC

| LM75B |

Industry Standard, , ±2°C Local, 11-bit ADC

Complexity

Local only — Remote & Local — Samples Now — In development
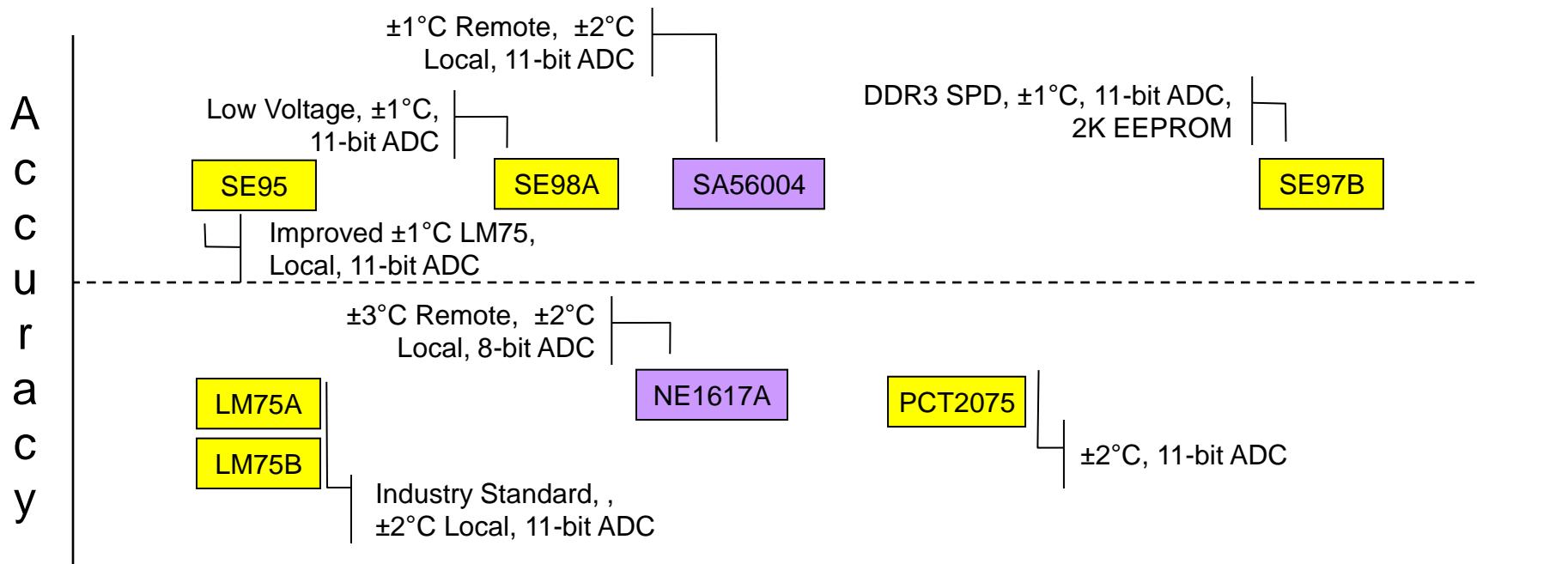
Thermal Sensor Selection Table

Part Number	Local Channels	Remote Channels	Accuracy Local (max)	Accuracy Remote (max)	Temp Resolution / A/D Resolution Bits	Power Supply Voltage Range	Supply Current Operating uA	Supply Current Standby uA	Package Option
LM75A	1		±2°C		0.125/11	2.8-5.5	1000	3.5	SO-8 TSSOP-8
LM75B	1		±2°C		0.125/11	2.8-5.5	300	1	SO-8 TSSOP-8 XSON-8 HWSON-8
NE1617A	1	1	±2°C	±3°C	1.0/8	3.0-5.5	70	3.0	QSOP-16
SA56004	1	1	±2°C	±1°C	0.125/11	3.0-3.6	500	10	SO-8 TSSOP-8
SE97B	1		±1°C		0.125/11	3.0-3.6	400	3	HWSON-8
SE98A	1		±1°C		0.125/11	1.7-3.6	400	5	TSSOP-8 HWSON-8
PCT2075	1		±2.0°C max, ±1.0°C typ		0.125/11	2.7-5.5	200	1	SO-8 TSSOP-8 HWSON-8 TSOP6

LM75B
Local Digital Temp. Sensor & Thermal Watchdog

Features

- Pin-for-pin replacement for industry standard LM75 and LM75A
- I^2C-bus interface - 8 devices on the same bus
- Power supply range from 2.8 V to 5.5 V
- Temperatures range from -55 °C to +125 °C
- Frequency range 20 Hz to 400 kHz with bus fault time-out to prevent hanging up the bus
- 11-bit ADC - temperature resolution of 0.125 °C
- Temperature accuracy of:
  - ±2 °C from -25 °C to +100 °C
  - ±3 °C from -55 °C to +125 °C
- Programmable temperature threshold and hysteresis set points
- Max supply current of 1.0 μA in shutdown mode
- Stand-alone operation as thermostat at power-up
- ESD protection exceeds 4500 V HBM per JESD22-A114, 450 V MM per JESD22-A115 and 2000 V CDM per JESD22-C101
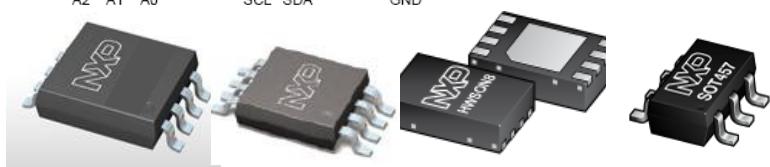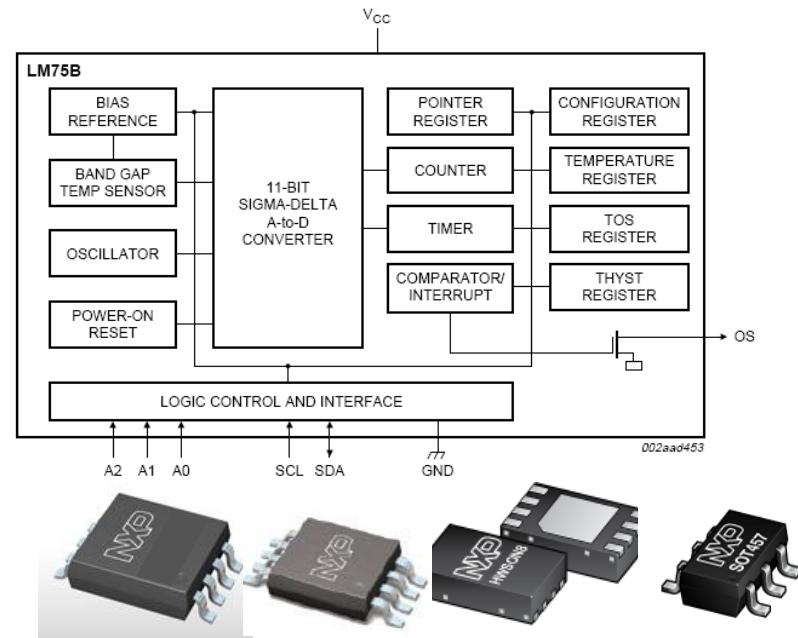- Small 8-pin package types: SO8 and TSSOP8
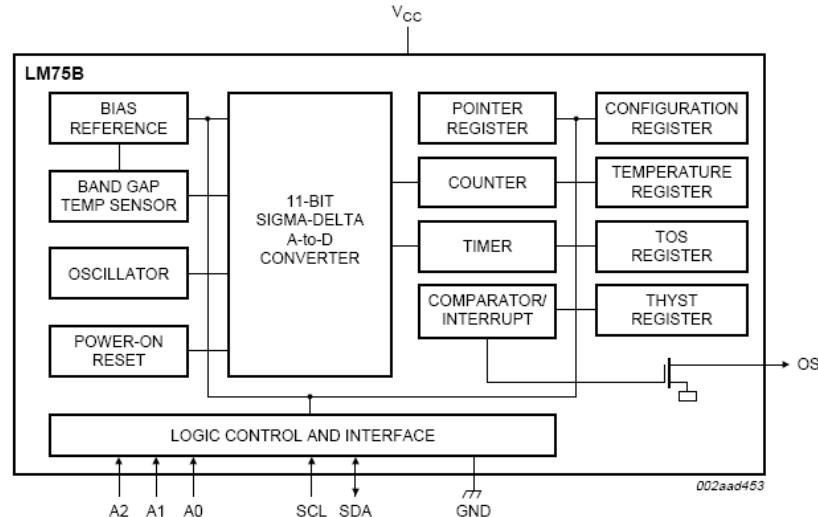
Type number	Topside mark	Package		
		Name	Description	Version
LM75BD	LM75BD	SO8	plastic small outline package; 8 leads; body width 3.9 mm	SOT96-1
LM75BDP	LM75B	TSSOP8	plastic thin shrink small outline package; 8 leads; body width 3 mm	SOT505-1
LM75BGD	75B	XSON8U	plastic extremely thin small outline package; no leads; 8 terminals; UTLP based; body 3 × 2 × 0.5 mm	SOT996-2
LM75BTP	M75	HWSON8	plastic thermal enhanced very very thin small outline package; no leads; 8 terminals, 2 × 3 × 0.8 mm	SOT1069-2

PCTx075: I²C-bus Temperature Sensors

FEATURES

- Fm+ I²C-bus (1MHz) with SMBus timeout
- Power supply range - 2.7 V to 5.5 V
- Temperatures range - -55 °C to +125 °C
- Programmable temperature threshold and hysteresis set points allows customer-defined default Tos & Thyst set points
- Tidle programmable adjustment for temperature sampling. Allows reduction in power consumption
- Stand-alone operation as thermostat at power-up
- Expanded I²C address range with 3 state pins (27 @ 8-pin and 3 @ 6-pin) address latched at power up
- 8-pin package types: SO8, MSOP8, HWSON8
- 6-pin package types: SOT23-6 (TSOP6)

11-bit ADC ± 2°C	PCT2075

PCTabcd – Fm+ thermal sensor
  a = accuracy ± °C
  b = modifier to base device
  cd = base device

PCT2075: 11-Bit ADC
  ±1 °C (max.) from −25 °C to +100 °C
  ±2 °C (max.) from −55 °C to +125 °C

Package	SO8	MSOP8	HWSON8	TSOP6 SOT23-6
SOT #	SOT96-1	SOT505-1	SOT1069-2	SOT457
Pitch (mm)	1.27	0.65	0.5	0.95
Width (mm)	3.90	3.0	2.0	3.0
Length (mm)	3.90	5.0	3.0	1.5
Height (mm)	1.75	1.1	0.8	1.1

SA56004 Application

Applications

▸ Energy Management

▸ Solar Panel System

▸ Building Controllers

▸ Heating and Cooling Controllers

▸ Industrial controllers and embedded systems
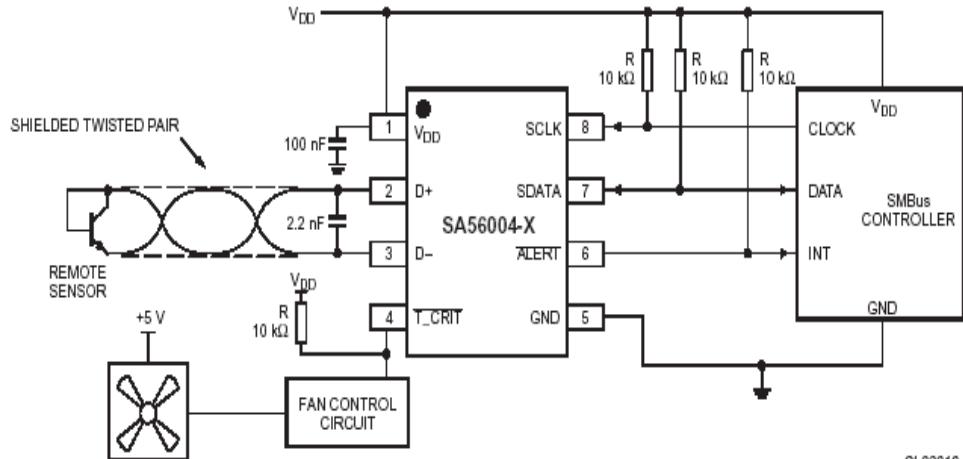
Features

▸ On-chip local and remote microprocessor thermal diodes or diode connected transistors temperature sensing within ±1 °C

▸ Offset registers available for adjusting the remote temperature accuracy

▸ Programmable under/over temperature alarms: ALERT and T_CRIT

▸ SMBus 2.0 compatible interface, supports TIMEOUT and 100/400 kHz I^{2}C interface

▸ 11-bit, 0.125 °C resolution

▸ 8 different device addresses are available for server applications. The SA56004-ED/EDH with marking code ARW is address compatible with the National LM86, the MAX6657/8 and the ADM1032.
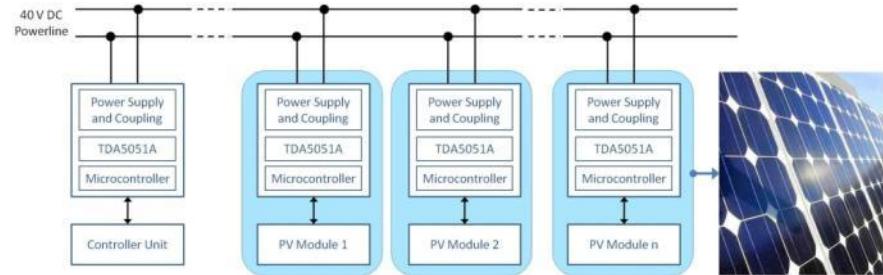
Backup

Power Line Modem

Power Line Modem Value Proposition

▶ **Why used?**
- Enables two-way communication between smart meters and appliances, for building automation
- Allow smart meters to track utilization by individual components

▶ **Where used?**
- Smart Energy Systems
  - Solar Panel Systems
  - Remote Diagnostics & Control
- Building Automation
  - HVAC Systems
  - Home appliance control (air conditioning, shutters, lighting, alarms, etc.)
  - Building security systems
- Intelligent power receptacles
- Energy (heating and cooling) control

http://www.theenergydetective.com/
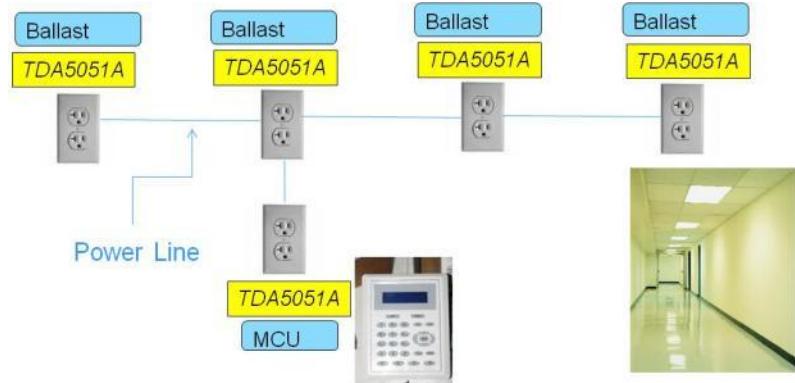
▶ **Why NXP PLC Modem?**
- Design requires few external components for low cost applications

TDA5051A: PLC Modem Application

▸ **Features**
  – Full digital carrier generation and shaping
  – Modulation/demodulation frequency set by clock adjustment, from microcontroller or on-chip oscillator
  – High clock rate of 6-bit D/A converter for rejection of aliasing components
  – Fully integrated output power stage with overload protection
  – Automatic gain control at receiver input
  – 8-bit A/D and narrow digital filtering
  – Digital demodulation delivering baseband data
  – Easy compliance with EN50065-1 with simple coupling network
  – Few external components for low cost applications
  – SO16 plastic package
 – Application Note (AN10903) available

▸ **Applications**
  – ASK (Amplitude Shift Keying) data transmission using the home power network
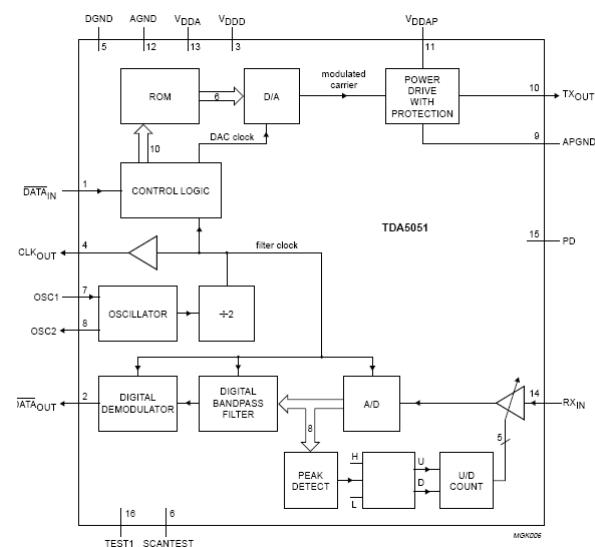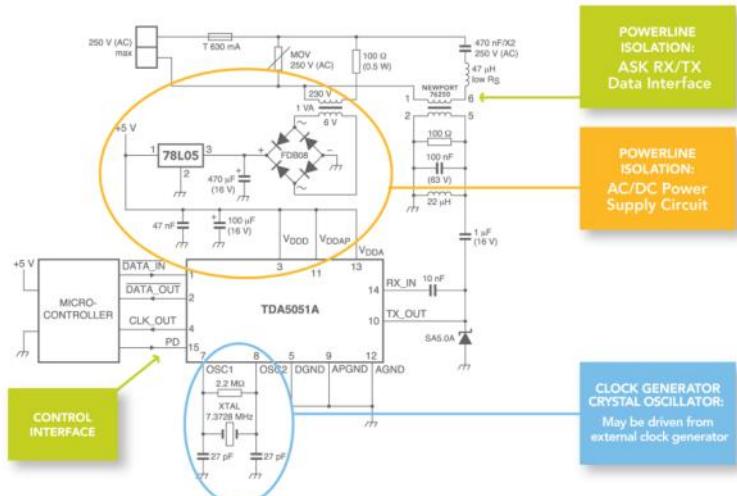
TDA5051A: Demonstration Kit (OM13313)

▸ A demo kit consists of two demo boards with AC power cords attached

▸ Evaluation board can be used for a 230-V (AC 50 Hz), a 120 V (AC 60 Hz), or a 0-V to 48-V DC mains power line

▸ If a galvanic isolated power transformer is used, it should be placed between the AC power line and the PLM evaluation board

▸ Select a power line plug/cable depending on power line supply voltage and safety enclosure used in test bench setup

▸ A user manual UM10422 is provided

▸ PLM interface connector
▸ TDA5051A PLM IC
▸ 8.0000 MHz fundamental crystal
▸ Murata 78250 conversion transformer
▸ Power Line inputs
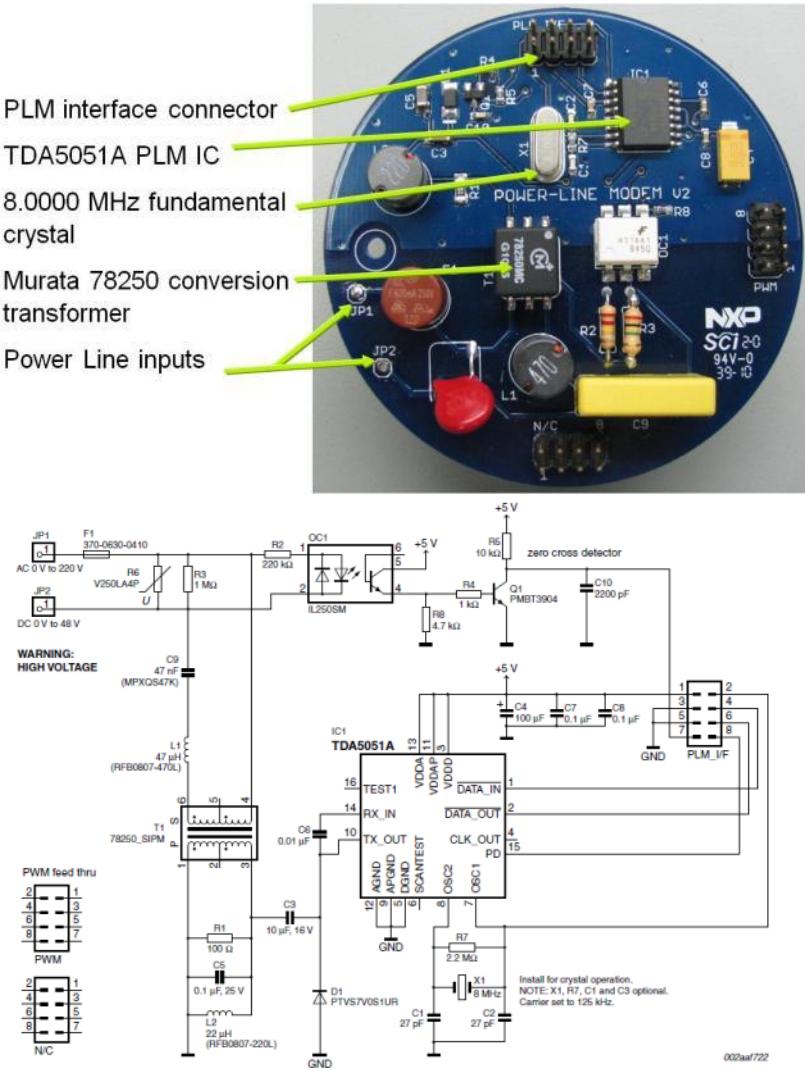
TDA5051A: Master/Slave Lighting Demo Kit (OM13314)

▸ A demo kit consists of two demonstration units with AC power cords attached

   – Master unit has 4 switches to select all four LEDs or individual LED on the slave unit, and to turn on/off or adjust brightness of selected LED(s)

   – Slave unit that drives LEDs

▸ Evaluation board can be used for a 230-V (AC 50 Hz), a 120 V (AC 60 Hz), or a 0-V to 48-V DC mains power line

▸ If a galvanic isolated power transformer is used, it should be placed between the AC power line and the PLM evaluation board

▸ Select a power line plug/cable depending on power line supply voltage and safety enclosure used in test bench setup

▸ A user manual UM10422 is provided

▸ Sample software will be included
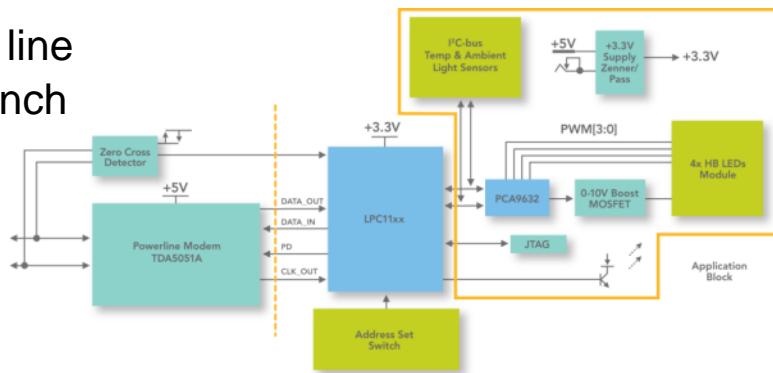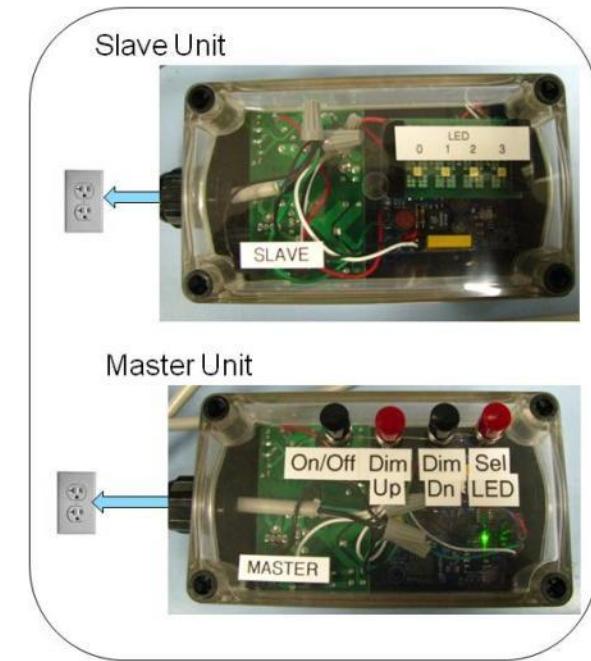
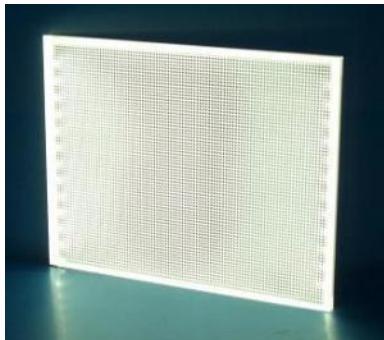# LED Controllers

LED Controllers Value Proposition

▸ **Why used?**
  – Offloads CPU from blinking operation

▸ **Where used?**
  – Equipment status indicator and control (Blinkers)
  – Keypad and LCD backlighting (Dimmers)
  – Brightness control (Dimmers)

▸ **Why NXP LED Controller?**
  – Large selection of LED Controllers in a wide range of packages
  – Minimized supply voltage ripple with programmable LED outputs phase shifting
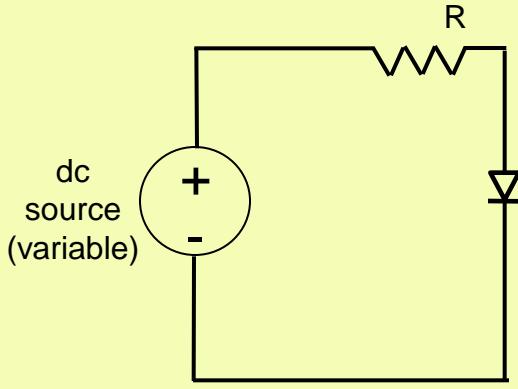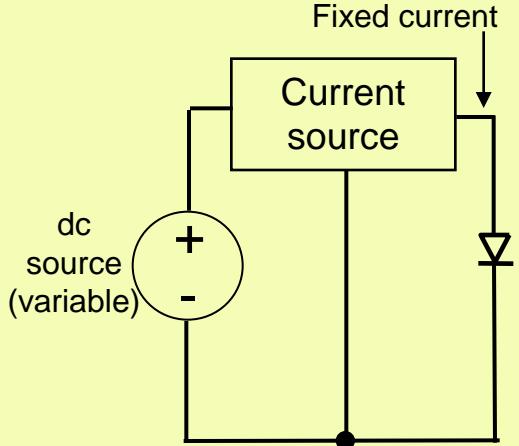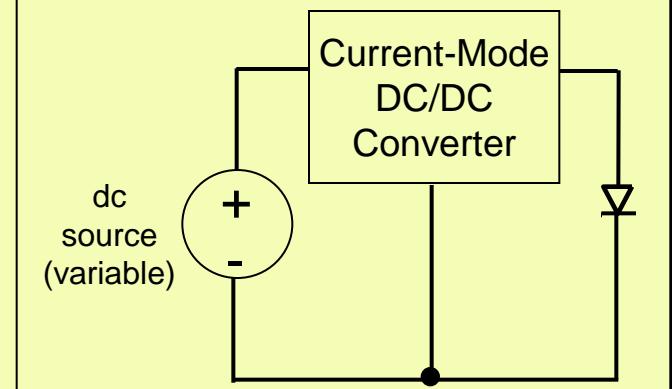 – Thermally enhanced HTSSOP package
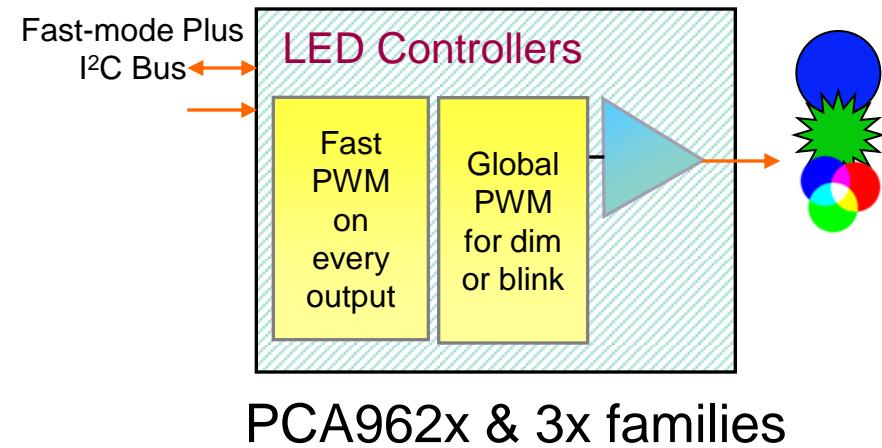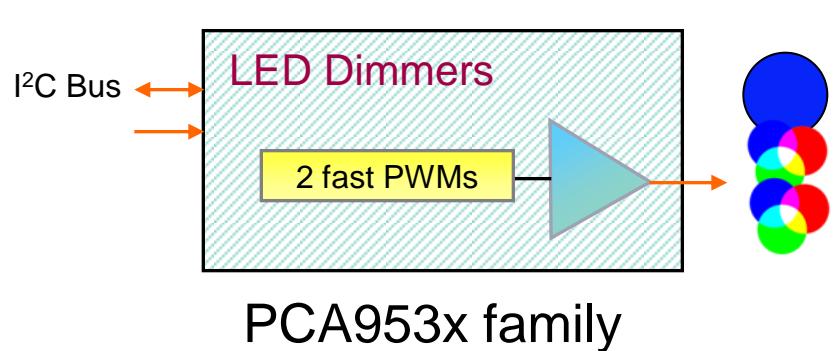
LED Stages & Backlighting   LCD Backlighting

Methods of Driving LEDs

Voltage Source + Resistor	Current Source	Current-Mode DC/DC Converter
$$I_F = \frac{V_{IN} - V_F}{R}$$	Fixed current Current source $I_F \approx constant$	Current-Mode DC/DC Converter $I_F \approx constant$
Pros: • Heat is dissipated in the resistor • Source is independent of heat dissipated • Good for driving multiple LEDs in series, with different V_F **Cons:** • I_F chances with V_{IN}	**Pros:** • LED light remains constant with supply voltage fluctuations **Cons:** • Heat is dissipated at the current source • Current source is sensitive to heat dissipation	**Pros:** • LED light remains constant with supply voltage fluctuations • Ability to step-up or step-down LED supply voltage • Good for directly driving LED when source and supply voltages are different. **Cons:** • More expensive

I²C LED Switch, Blinkers, Dimmers and Controllers

Product overview

Fast-mode Plus
I²C Bus

LED Switch (GPIOs)

PCA967x family

I²C Bus

LED Blinkers

2 slow PWMs

PCA955x family

I²C Bus

LED Dimmers

2 fast PWMs

PCA953x family

Fast-mode Plus
I²C Bus

LED Controllers

Fast PWM on every output

Global PWM for dim or blink

PCA962x & 3x families
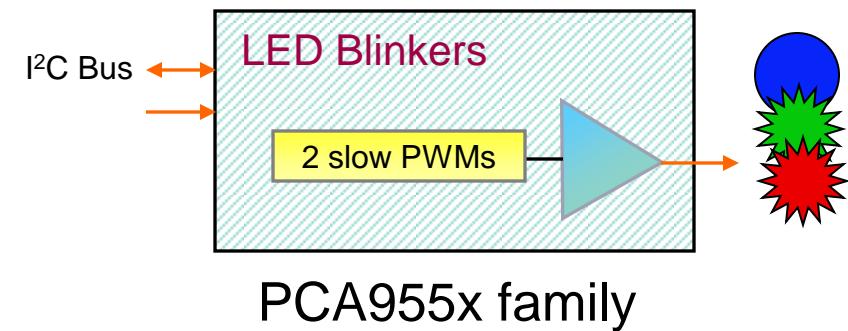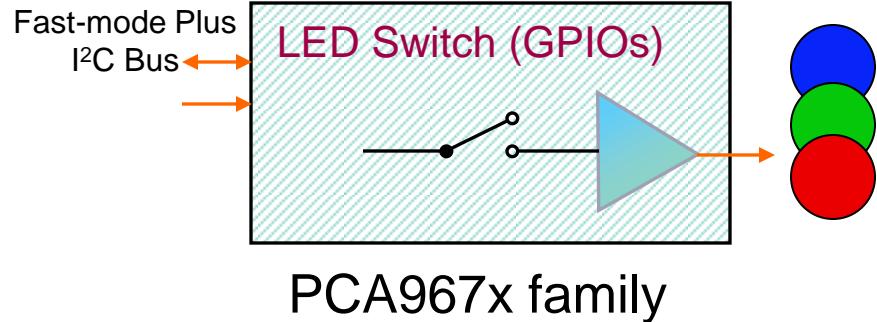
LED Controller Portfolio

Voltage-Source LED Controllers

Number of Outputs	LED Blinkers (25mA / 5V)	LED Dimmers (25mA / 5V)	Color Mixing LED Controllers (25mA / 5V)	Color Mixing LED Controllers (100mA / 40V)
2	PCA9550	PCA9530		
4	PCA9553	PCA9533	PCA9632 [1] PCA9633	
8	PCA9551	PCA9531	PCA9634	PCA9624
16	PCA9552	PCA9532	PCA9635 PCA9685 [2]	PCA9622
24				PCA9626

[1] Low power version of PCA9633
[2] The PCA9685 has 12-bit PWM while the PCA9635 has 8-bit PWM

Current-Source LED Controllers

Device	# of Outputs	F_{OSC}	Output Current	Active-Low /OE	Interface
PCA9922	8	None	15mA ~ 60mA	Yes	25-MHz Serial Shift Interface
PCA9952	16	8MHz	5mA ~ 57mA	Yes	Fm+ I2C; 8 Address
PCA9955	16	8MHz	5mA ~ 57mA		Fm+ I2C; 16 Address

LED Controllers Applications: PCA962x LED Controller

Features:

▸ Programmable LED drivers

▸ Outputs drive up to100-mA (per output)

▸ Open-drain outputs allow voltages up to 40V

▸ Individual LED dimming with 8-bit or 256 steps individual PWM

▸ Global LED dimming or blinking with 8-bit or 256 steps individual PWM

▸ 124 individual addresses with 4 programmable sub calls address groups

▸ Fast-mode Plus I^{2}C interface (1MHz)

PCA9624	8-Bit
PCA9622	16-Bit
PCA9626	24-Bit

Benefits:

▸ Same software as PCA963X

▸ Drive up to 100mA @ 40 V, with LEDs in series

Applications:

• High-voltage lighting environment
• RGB or RGBA LED driving for color mixing
• High-current drive LEDs
• LCD backlight applications
• Keypad backlight applications
• LED light bars
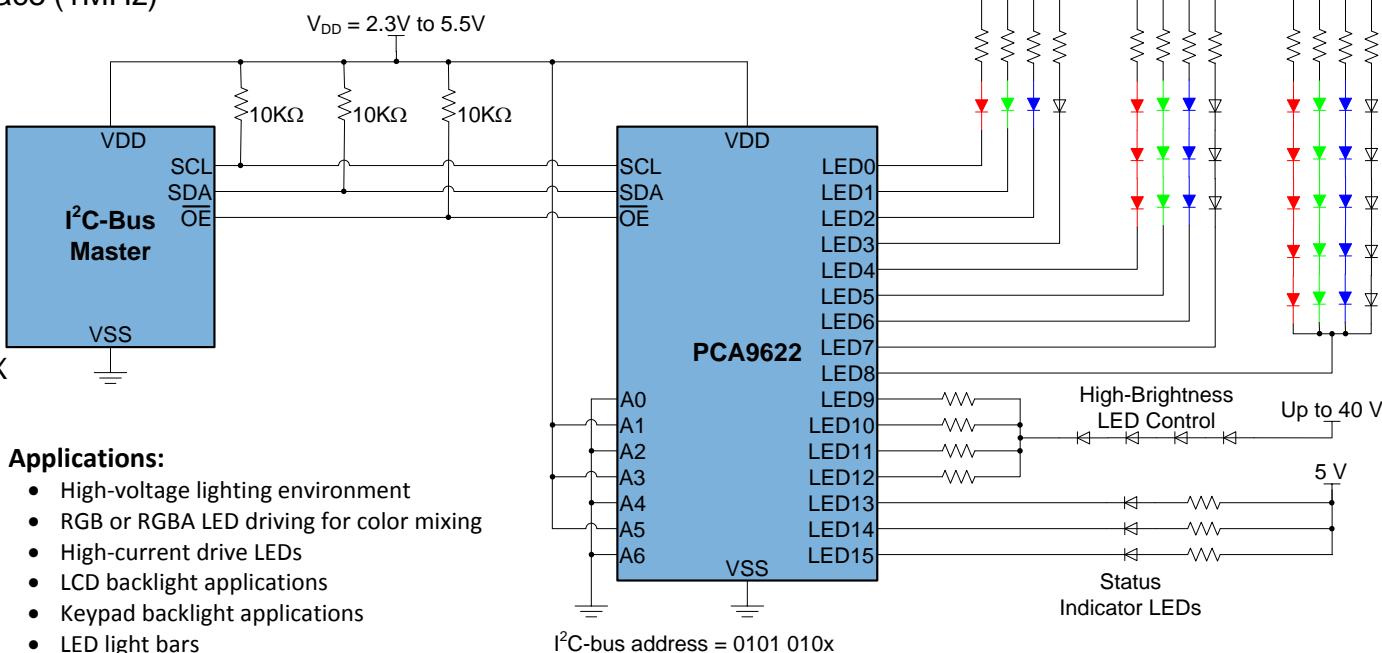
PCA9952/55: 20V / 57mA Constant-Current LED Controller

## FEATURES

‣ V_{CC} = 3.0 V t o 5.5 V
‣ Output
  – Constant current; Up to 57mA current drive/channel
  – 20V sustaining voltage
  – R_{EXT} sets I_{LED} for all channels
  – ±6% channel-to-channel matching
  – ±8% IC-to-IC matching
  – 0.8V (typ) regulation voltage
  – 256:1 LED current peak adjustment
  – LED short/open detect
‣ Digital Interface
  – I²C (Fm+), 1 MHz (bi-directional)
  – Four H/W address pins with PCA9955 (For PCA9952, A3=/OE)
  – Four software programmable I²C-bus addresses (one LED group call address and three LED sub call addresses)
‣ PWM Generator
  – 256:1 Individual PWM dimming range (31.25kHz)
  – 256:1 Global PWM dimming range (122Hz)
  – 256:1 Global blinking (0.05Hz to 15Hz)
  – Programmable phase shifting (125ns to1.875us)
‣ Over-Temperature Protection (150 ˚C typ)
‣ 28-Lead, HTSSOP, 4.4-mm body width, exposed die pad
‣ -40 ˚C to +85 ˚C Operating Temperature
‣ Compliant to ESD Standards (2kV HBM, 200V MM)

Simplified Applications Diagram
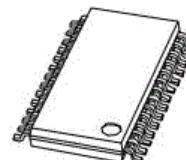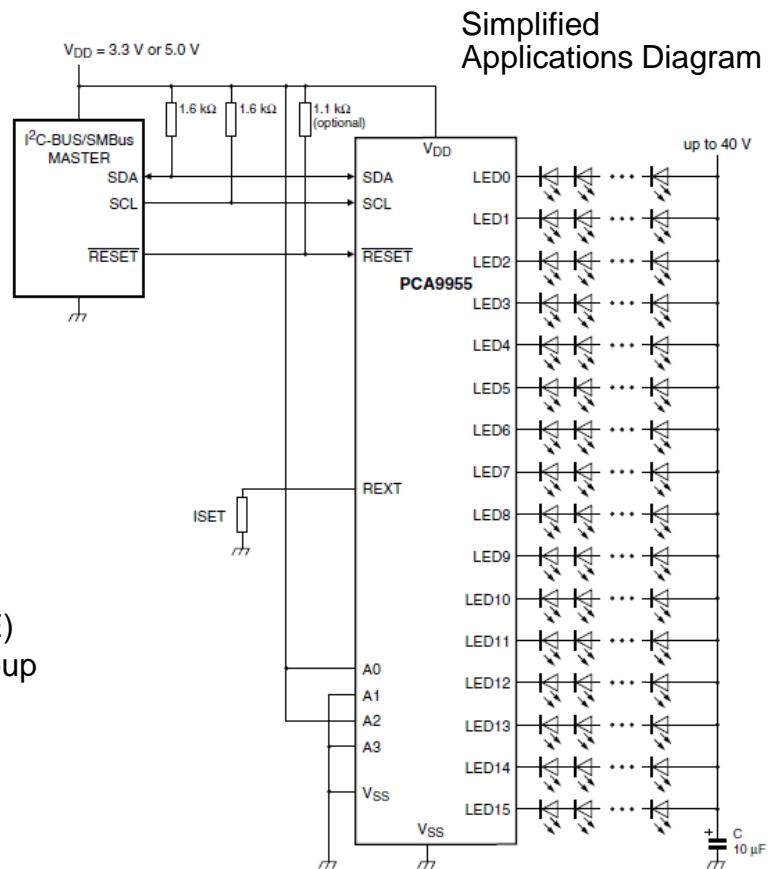
LED Controllers Demo Boards Support

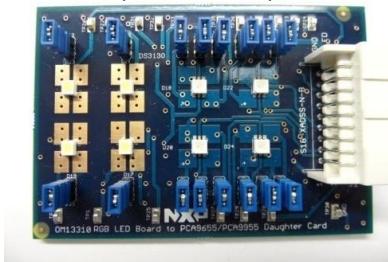## 16 White LED Board
(**OM13311**)
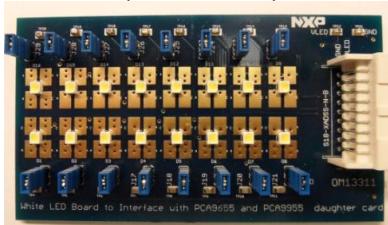
OR

4 RGB + 4 White LED Board
(**OM13310**)

PC GUI

OM Number	Description (Device)
OM6275 †	I2C2005-1 Demo Board (PCA9531 & PCA9551)
OM6282 †	4-Channel Fm+ Voltage Switch LED Controller Demo Board (PCA9633)
OM6276 †	4-Channel Fm+ Voltage Switch LED Controller Demo Board (PCA9633)
OM13269 †	4-Channel Fm+ Voltage Switch LED Controller Demo Board (PCA9632)
OM13327 †	8-Channel Fm+ Voltage Switch LED Controller Demo Board (PCA9634)
OM13332 †	16-Channel Fm+ Voltage Switch LED Controller Demo Board (PCA9685)
OM13333 †	16-Channel Fm+ Voltage Switch LED Controller Demo Board (PCA9635)
OM13329	16-Channel Fm+ Constant Current LED Controller Demo Board (PCA9952)
OM13309	16-Channel Fm+ Constant Current LED Controller Demo Board (PCA9955)
OM13330 †	16-Channel Fm+ Constant Current LED Controller Demo Board (PCA9955)
OM13483	16-Channel Fm+ Constant Current LED Controller Demo Board (PCA9955A)
OM13321	24-Channel Fm+ Constant Current LED Controller Demo Board (PCA9956A)
OM13331 †	16-Channel UFm Constant Current LED Controller Demo Board (PCU9955)
OM13310	4-RGB + 4-White LED Board
OM13311	16-White LED Board

† Available on eDemoboard

PCA9955 Board
(**OM13309**)

WinI2C Dongle
(or any I^{2}C-bus Master)

PCA9633 Board
(**OM6276**)
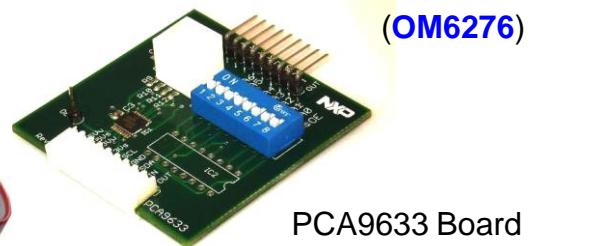
PCA9633 Board
(**OM6282**)

Stepper Motor Controller

Stepper Motor Controller Value Proposition

▸ **Why used?**

  – Offload CPU/Microcontroller from driving control signals to the motor driver

▸ **Where Used?**

  – HVAC Compressors and blowers

  – Industrial motors

  – Variable-speed fans and pumps

  – Medical pumps and blowers

▸ **Why NXP Stepper Motor Controller?**

  – Supports different commands (start, stop, ramp-up, ramp-down, direction control, etc.).

  – Interfaces with different stepper motors as drivers are external.

  – Easy integration in the system with I^2C interface.
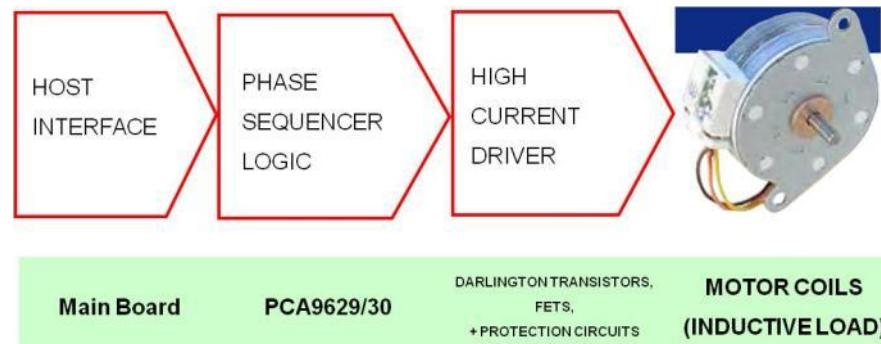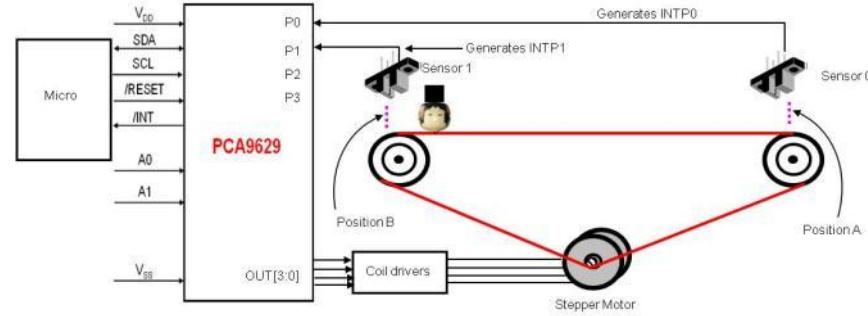
PCA9629 1-Channel Stepper Motor Controller

Features

▸ Provide drive signals for driving a single stepping motor:
- One, Half and Two Phase Drive Control
- Start, stop, ramp-up/ramp-down and direction control of stepper motors
- Programmable steps per rotation allows use of many models of stepper motors
- Programmable step pulse width to control speed of motor
- Balanced push-pull outputs: Drives 1000 pF loads with 15 ns rise and fall times

▸ Interrupt linked extra steps, direction reversal and stop control

▸ Four GPIOs programmable as inputs or push-pull outputs (25 mA) to sense optical interrupter for motor home position or drive solenoid/LEDs, respectively

▸ Stand alone operation: Off loads microcontroller

▸ Hardware RESET to recover from bus stuck condition

Inputs: V_{DD}, SDA, SCL, /RESET, /INT, A0, A1, V_{SS}

PCA9629

OUT0, OUT1, OUT2, OUT3 — Coil drive pins (4)

P0, P1, P2, P3 — GPIO pins (4)

TSSOP20
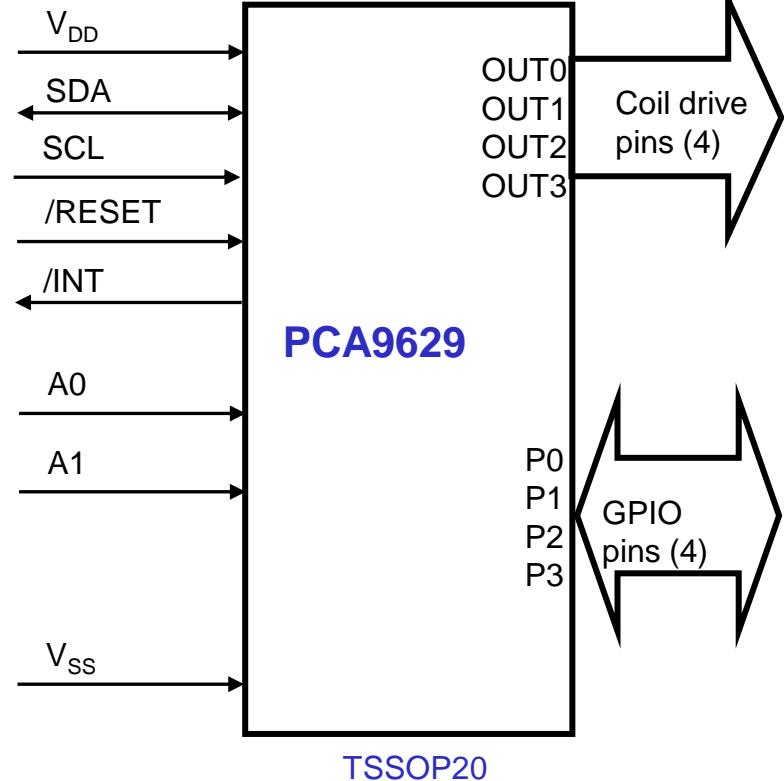
Potential applications

▸ Industrial Control

▸ White Goods

▸ Gaming & Vending Machines

▸ PTZ Camera
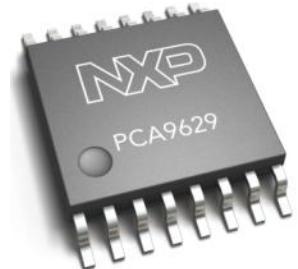
PCA9629: Evaluation Kit (OM13285)

▸ **PCA9629 Demo Board Block Diagram**
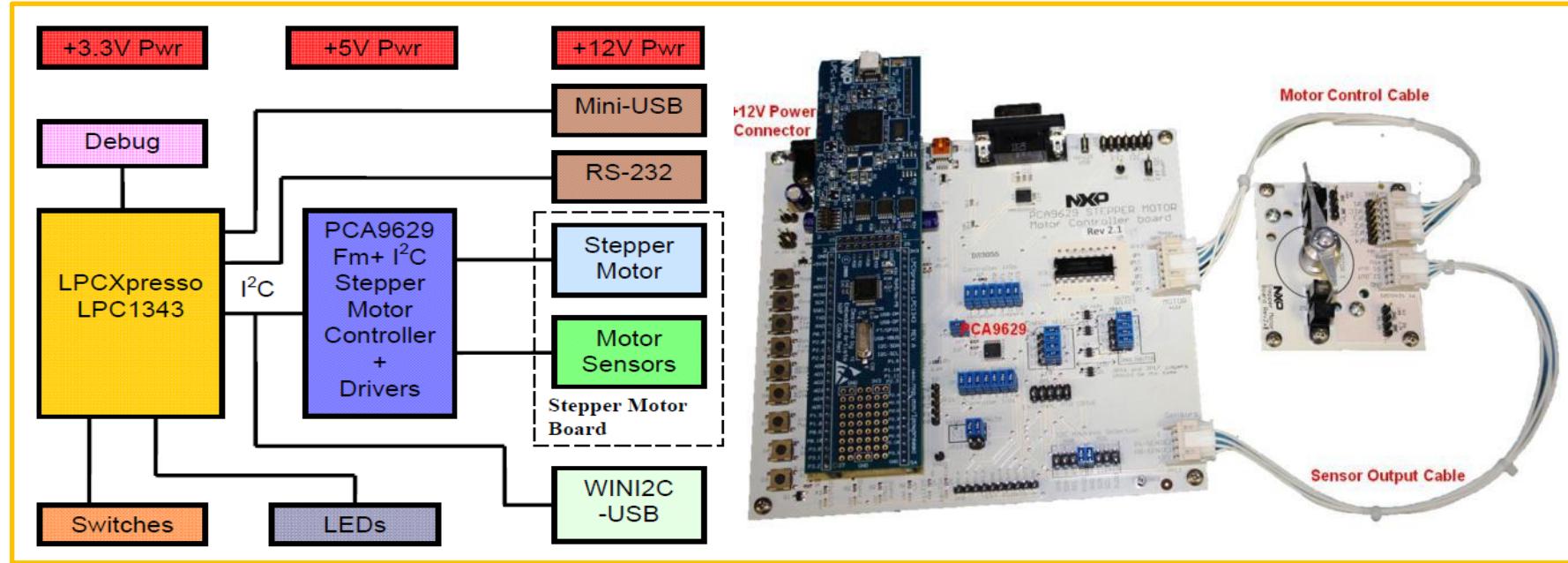
▸ **LPC1343 (32-bit ARM Cortex-M3 Microcontroller)**
– Used to control the PCA9629 Stepper Motor Controller
– LPC link can be plugged into the board
– Software can be modified using LPCXpresso tools

▸ **The PCA9629 Stepper Motor Controller Demo Board only has Part Number OM13321**

OM13285 is available on eDemoboard

UART's

UART's Value Proposition

▸ **Why used?**
  – Transmits and receives data transfer between processor and communication channel
  – Checks communication error and relieves processor from the task of managing communication errors

▸ **Where used?**
  – Communication channels

▸ **Why NXP UARTs?**
  – Established committed long-term supplier
  – Broad portfolio in the industry
  – Number #1 supplier for Industrial UARTs
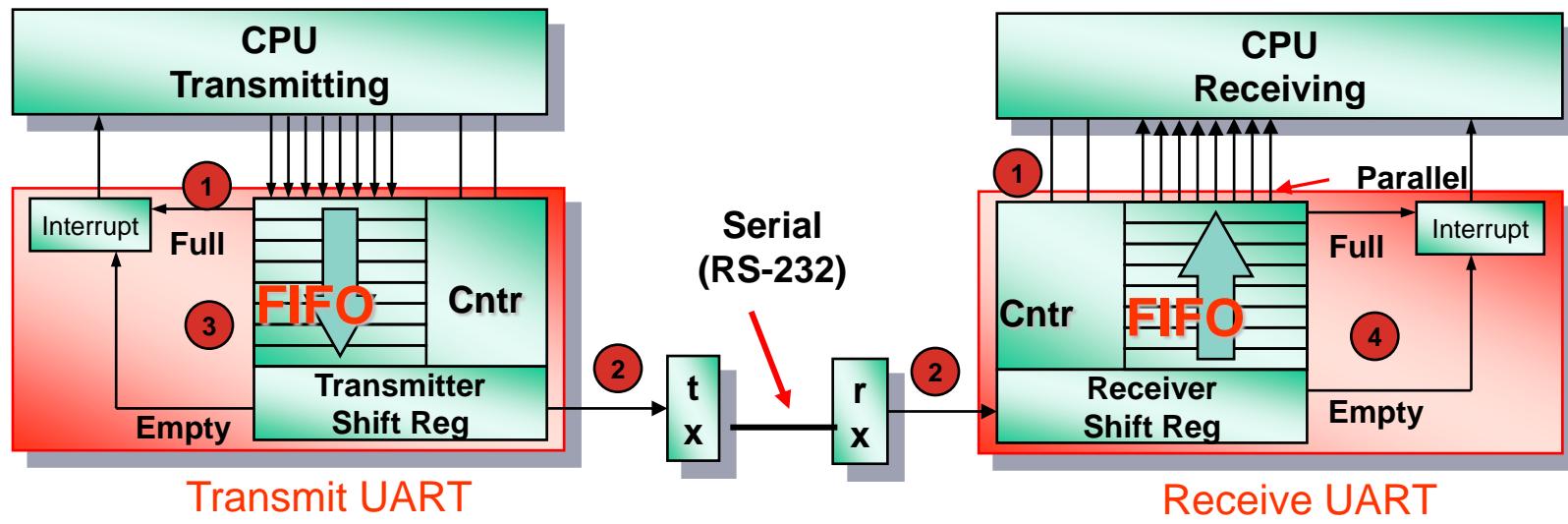
Industrial UART Family

Features	Benefits
Broad line of single to octal channel UARTs	Variety of choices for different applications
Industry-grade temperature range (-45 to 80 ˚C)	Rugged performance in extreme conditions
Power-down mode	Ideal for battery-operated systems
Extensive interrupt support	Reduced software overhead
Automatic RS485 half-duplex control	Reduced CPU overhead (multi-drop support)
Automatic out-band flow control	Avoids loss of data
RX/TX Independent with respect to speed & clock frequency	RX/TX can operate at different baud rates
Flexible and programmable I/O structure	Allows usage of I/O pins for general purposes
RTS/CTS (hardware) flow control signals	Prevent receiver overrun
3.3V and 5V operating range (IMPACT Family)	Broader range of application
Motorola/Intel interfaces (IMPACT Family)	Industry-standard compatibility and faster design-in

SCxxxx Series
- Baseline architecture
- 3-deep receive FIFOs

SC26/8xxx Series
- 9-deep FIFOs
- Higher baud rates
- Faster bus

SC28Lxx Series
- 16 to 256-deep FIFOs
- 3V to 5V operation
- Xon / Xoff Feature

IMPACT Family

Number of Channels

8 — SCC2698B — SC28L198

4 — SC28C94 — SC28L194

2 — SCC2681 / SCC68681 — SCC2692 / SCC68692 — SCC26C92 — SC28L92 — SC28L202

1 — SCC2691 — SC28L91 — SC28L201

Migration Path: Performance per Channels

SC28L201/202 Highlights

- Single (SC28L201) and Dual (SC28L202) channels UART
- Full duplex independent UART
- 256-byte FIFO for receiver and transmitter
- 13 programmable I/O ports
- 3V and 5V operation with 5V-tolerant inputs
- Pin programming for Motorola or Intel bus interfaces
- Baud Rates up to 3.125Mbps
- Auto RTS/CTS and Xon/Xoff Flow Control
- Power-down mode (< 10µA)
- Xon/Xoff Character Recognition
- 16-bit programmable Counter/Timer
- Intelligence Interrupt Arbitration (I2A)
- Auto Wake-up (9-bit) mode for RS485 applications
- Line break detection and Change of state detection
- Receiver Time-out mode and Watchdog timer for receiver
- Real time transmission Error check
- UART channels mode for system debugging
- Interrupt Request and Acknowledgement pins
- Industrial temperature at Commercial pricing
- 48-pin TSSOP package

Pin	Signal		Pin	Signal
1	Vcc		48	X2
2	Vss		47	X1/SCLK
3	A6		46	IRQN
4	A5		45	TXD
5	A4		44	I/O0A
6	A3		43	I/O1A
7	RXD		42	I/O2A
8	RESET		41	I/O3A
9	D7		40	I/O4A
10	D6		39	I/O5A
11	D5		38	I/O6A
12	D4		37	I/O7A
13	Vcc		36	Vss
14	Vss		35	Vss
15	D3		34	Vcc
16	D2		33	I/O0B
17	D1		32	I/O2B
18	D0		31	I/O3B
19	I/M		30	I/O4B
20	A2		29	I/O6B
21	A1		28	RDN
22	A0		27	WRN
23	IACKN		26	CEN
24	Vcc		25	Vss

High-Performance Single Channel UART

SC28L201A1DGG
80xxx mode

002aab421

Intel and Motorola Conversion
WRN -> R/WN
RDN -> DACKN

88

Commercial 16CxxxB UART Family

Features	Benefits
Broad line of single to quad channel UARTs	One-stop shopping
Widest supply range (2.5V, 3.3V, 5V) at industrial temperature range (-40˚C to 85˚C) without price premium	Single part can be used for multiple systems and multiple operating environments. Lower overall cost of ownership – can replace up to four competitor parts.
Fastest device on the market with over 20% faster bus cycle times and baud rates up to 5Mbps	Compatible with high-speed processors
Power-down mode	Ideal for battery-operated systems
HVQFN and BGA package options	Ideal for small, portable systems
Windows and Linux OS-compatible	Simplifies software development
Infrared (IrDA) interface	Enables wireless, short-range applications
Software readily available	Shortens design cycle
Automatic software and hardware flow control	Reduces CPU overhead and data loss
DMA mode and wide variety of FIFO depths	Increases system throughput
Drop-in compatibility with existing 16C devices	Alternative source to other manufacturers
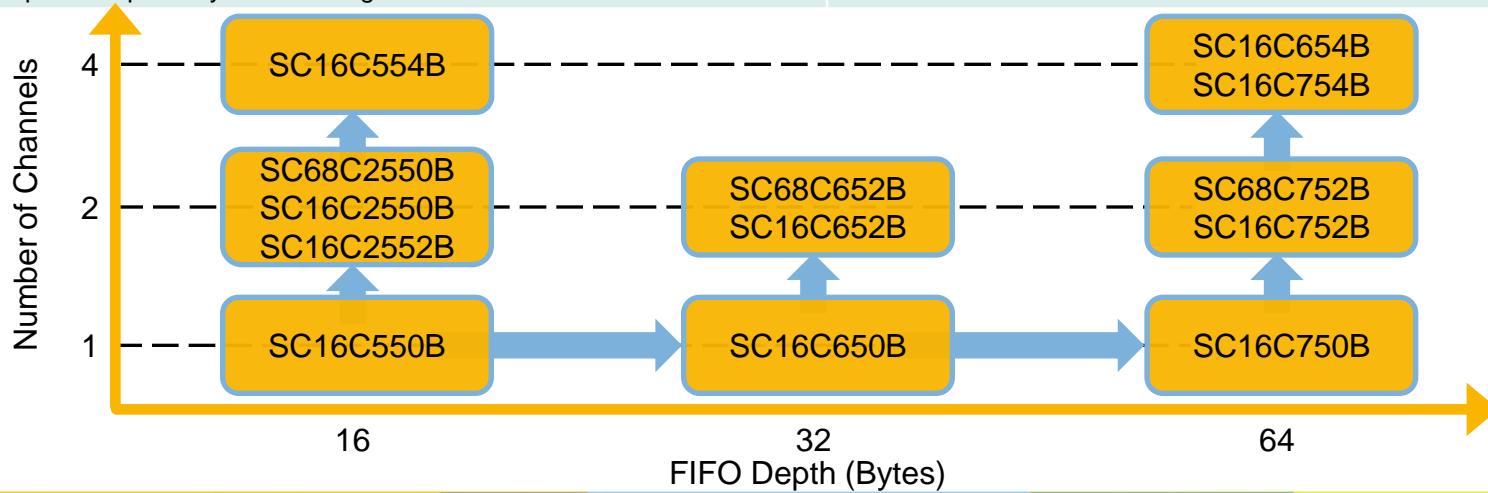
SC16C85xx: 1.8V – 3.3V UARTs

- Single- and dual-channel UART

- Intel/Motorola and VLIO interface

- Sleep Mode / Low Power mode

- up to 5Mbps

- 128 bytes Tx / Rx FIFOs

- Automatic RS485

- IrDA version 1.0

- Independent UART Tx and Rx enable/disable

- Ultra small: TFBGA

SC16C850IBS/Q900

- UART with 16-mode or 68-mode parallel bus interface; -40°C to +85°C; HVQFN32; AEC-Q100 compliant automotive qualification

(Analog Sensors- Temperature, Humidity, Lights)

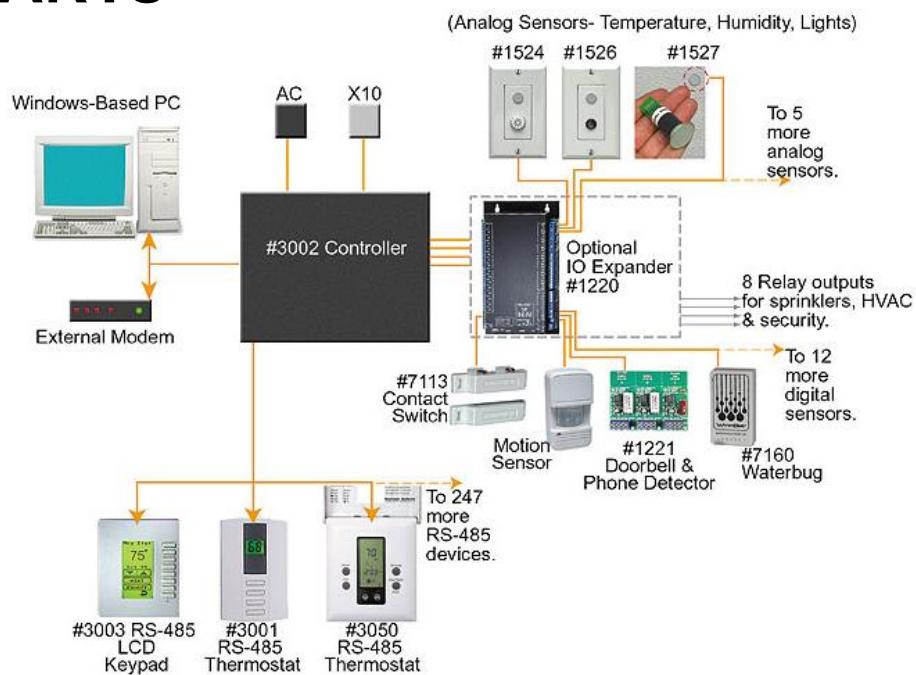| Part Number	CH	Host Interface	V_{CC}	TFBGA (3.5x3.5)	HVQFN (5x5)	LQFP (7X7)
SC16C850L	1	Intel / Motorola	1.8 V	√	√	TBD
SC16C850V	1	VLIO	1.8 V	TBD	√	
SC16C852L	2	Intel / Motorola	1.8 V	TBD	√	√
SC16C852V	2	VLIO	1.8 V	√	√	TBD

SC16C85xxS: 1.8V – 3.3V UARTs

- Single- and dual-channel UART

- Intel/Motorola and VLIO interface

- Sleep Mode / Low Power mode

- Programmable Sampling Rates up to 20Mbps

- 128 bytes Tx / Rx FIFOs

- Automatic RS485

- IrDA version 1.0

- Independent UART Tx and Rx enable/disable

- Ultra small: TFBGA

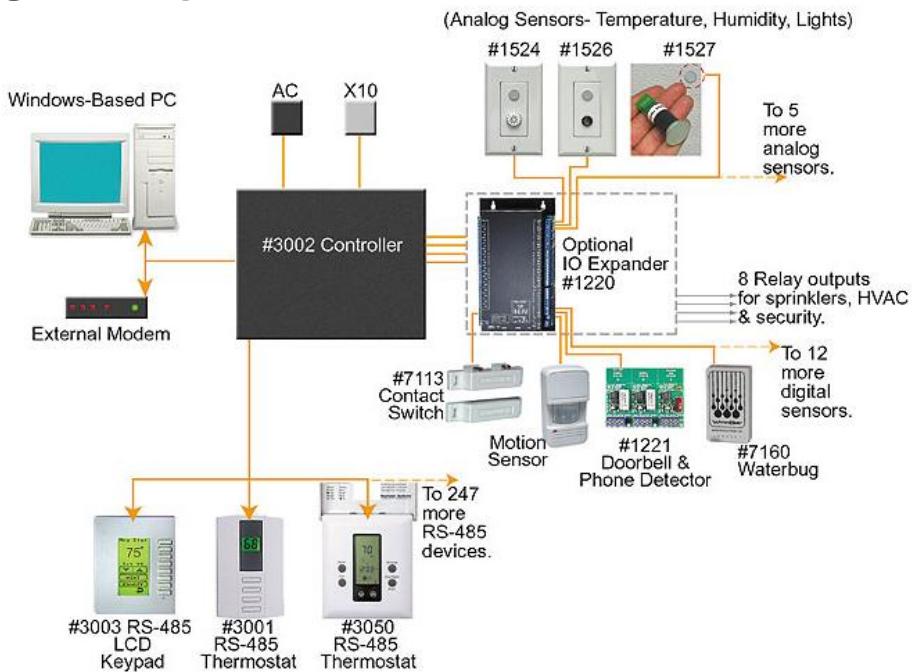| Part Number	CH	Host Interface	V_{CC}	TFBGA (3.5x3.5)	HVQFN (5x5)	LQFP (7X7)
SC16C850SL	1	Intel / Motorola	1.8 V	√	√	TBD
SC16C850SV	1	VLIO	1.8 V	TBD	√	
SC16C852SL	2	Intel / Motorola	1.8 V	√	√	√
SC16C852SV	2	VLIO	1.8 V	√	√	TBD

Bridges

What is a Bridge IC?

▸ New generation of interface solutions for managing communication among various bus interfaces

▸ The purpose is to overcome the limitations of the host bus interface to the peripherals

UART		UART
I^{2}C		I^{2}C
SPI		SPI
		IrDA
		GPIO

▸ Benefit :
   – Greater design flexibility
   – Ability to retain original design investment
   – Faster time to market
   – Link legacy and new systems and vice versa

Selecting a Bridge IC

FROM \ TO	UART	I²C	SPI
UART		SC18IM700	
I²C	SC16IS740 SC16IS75x SC16IS76x SC16IS850L		SC18IS602B
SPI		SC18IS600	

I²C/SPI-to-UART Bridges

Part #	UART	FIFO	SPI	GPIO
SC16IS740	1	64	4Mbps	–
SC16IS750	1	64	4Mbps	8
SC16IS752	2	64	4Mbps	8
SC16IS760	1	64	15Mbps	8
SC16IS762	2	64	15Mbps	8
SC16IS850L	1	128	12Mbps	–

UART-to-I²C Bridge

Part #	UART	I²C	GPIO	CLK
SC18IM700	460.8kbps	400kHz	8	Int

SC16IS740IPW/Q900

▸ Fully featured standalone UART (IrDA) with I²C/SPI interface and 64byte FIFOs; -40°C to +85°C; TSSOP24; AEC-Q100 compliant automotive qualification

SPI-to-I²C Bridges

Part #	SPI	I²C	GPIO	CLK
SC18IS600	1Mbps	400kHz	4	Int

I²C-to-SPI Bridges

Part #	SPI	I²C	GPIO	CLK
SC18IS602B	1.8Mbps	400kHz	4	Int

Multiplexers & Switches

Multiplexes & Switches Value Proposition

- ▸ **Why used?**
  - Address conflict resolution if two devices with same address need to be on the same bus
  - Voltage level translation to allow devices with different voltage supplies to operate on the same I^{2}C-bus
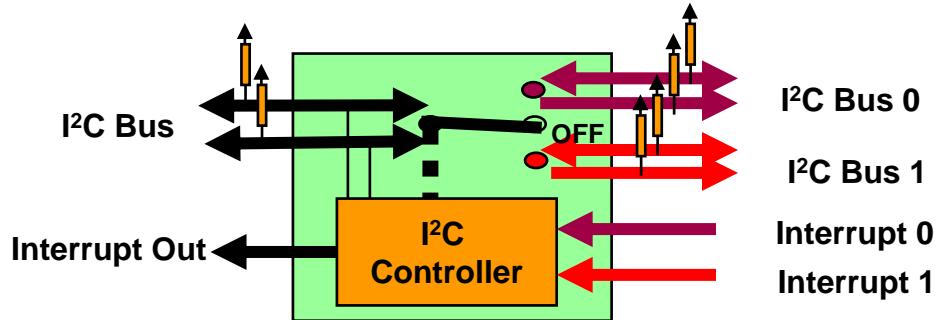 - Broadcast communication to identically addressed slaves

- ▸ **Where used?**
  - BACnet controller cards, power suppliers, and anywhere that requires the I^{2}C-bus to be split

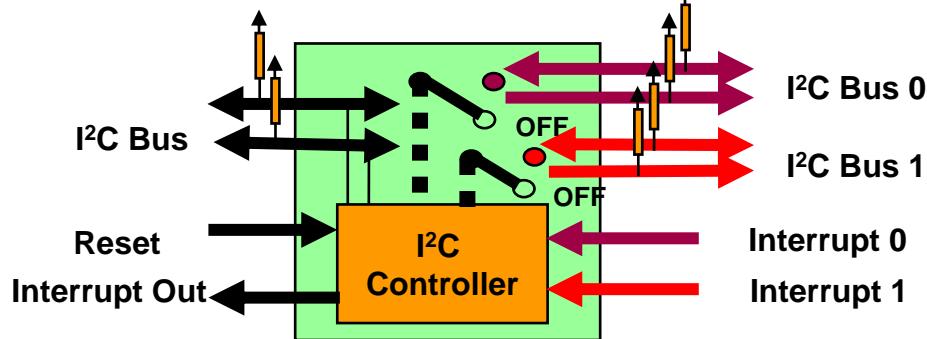- ▸ **Differences between Multiplexers & Switches?**
  - A mux can select only one channel at a time, while a switch can select one or more channels at a time.
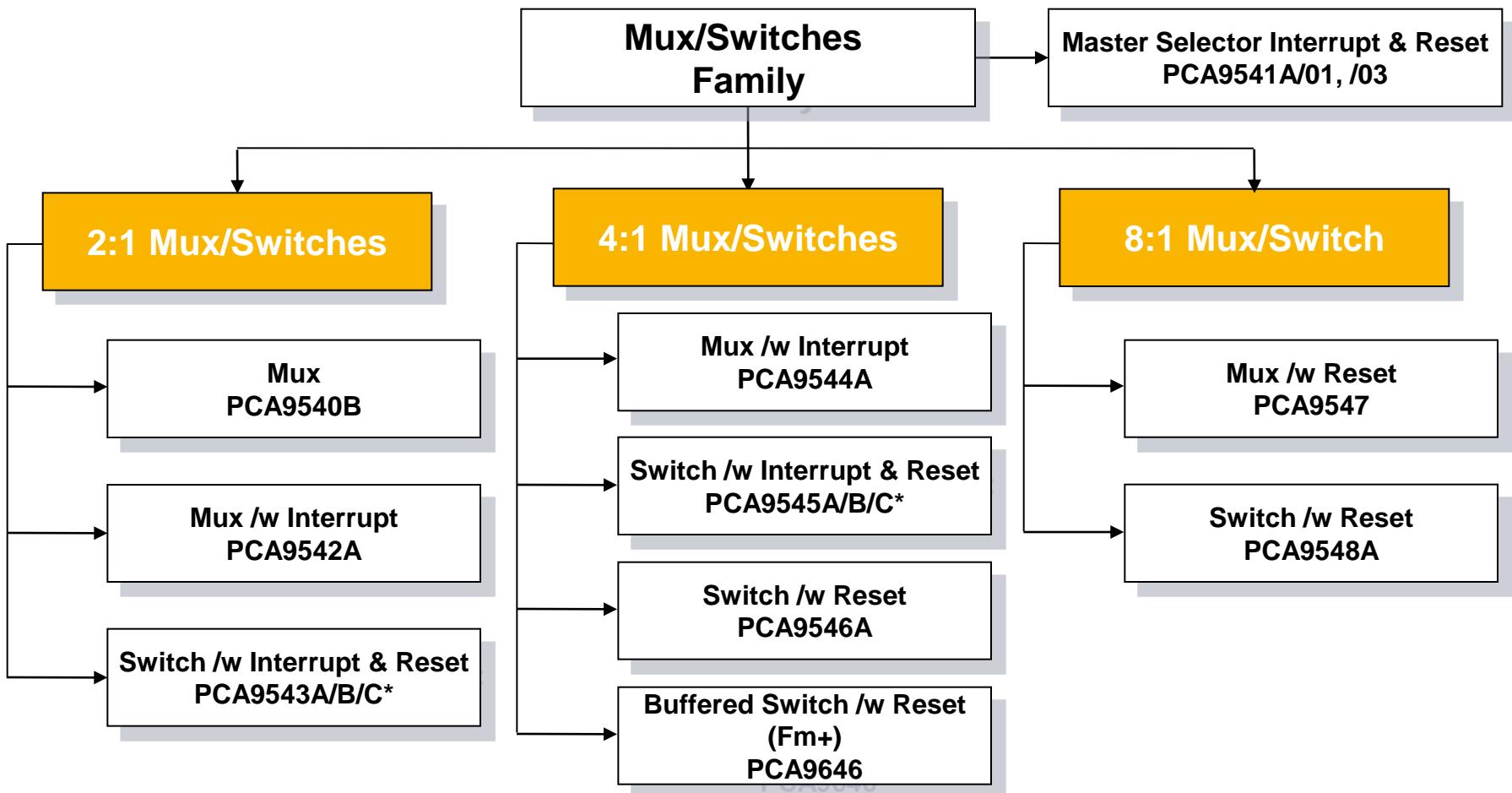
    Application Note AN262

Multiplexer
Can only select one downstream channel at a time

Switch
Can select one or more downstream channels at a time. Multiple channels are selected in broadcast mode.

Multiplexer / Switch Family

```
                        ┌──────────────────┐              ┌────────────────────────────────┐
                        │   Mux/Switches   │─────────────▶│ Master Selector Interrupt & Reset │
                        │     Family       │              │      PCA9541A/01, /03          │
                        └──────────────────┘              └────────────────────────────────┘
```

2:1 Mux/Switches	4:1 Mux/Switches	8:1 Mux/Switch

2:1 Mux/Switches

- Mux
  PCA9540B
- Mux /w Interrupt
  PCA9542A
- Switch /w Interrupt & Reset
  PCA9543A/B/C*

4:1 Mux/Switches

- Mux /w Interrupt
  PCA9544A
- Switch /w Interrupt & Reset
  PCA9545A/B/C*
- Switch /w Reset
  PCA9546A
- Buffered Switch /w Reset (Fm+)
  PCA9646

8:1 Mux/Switch

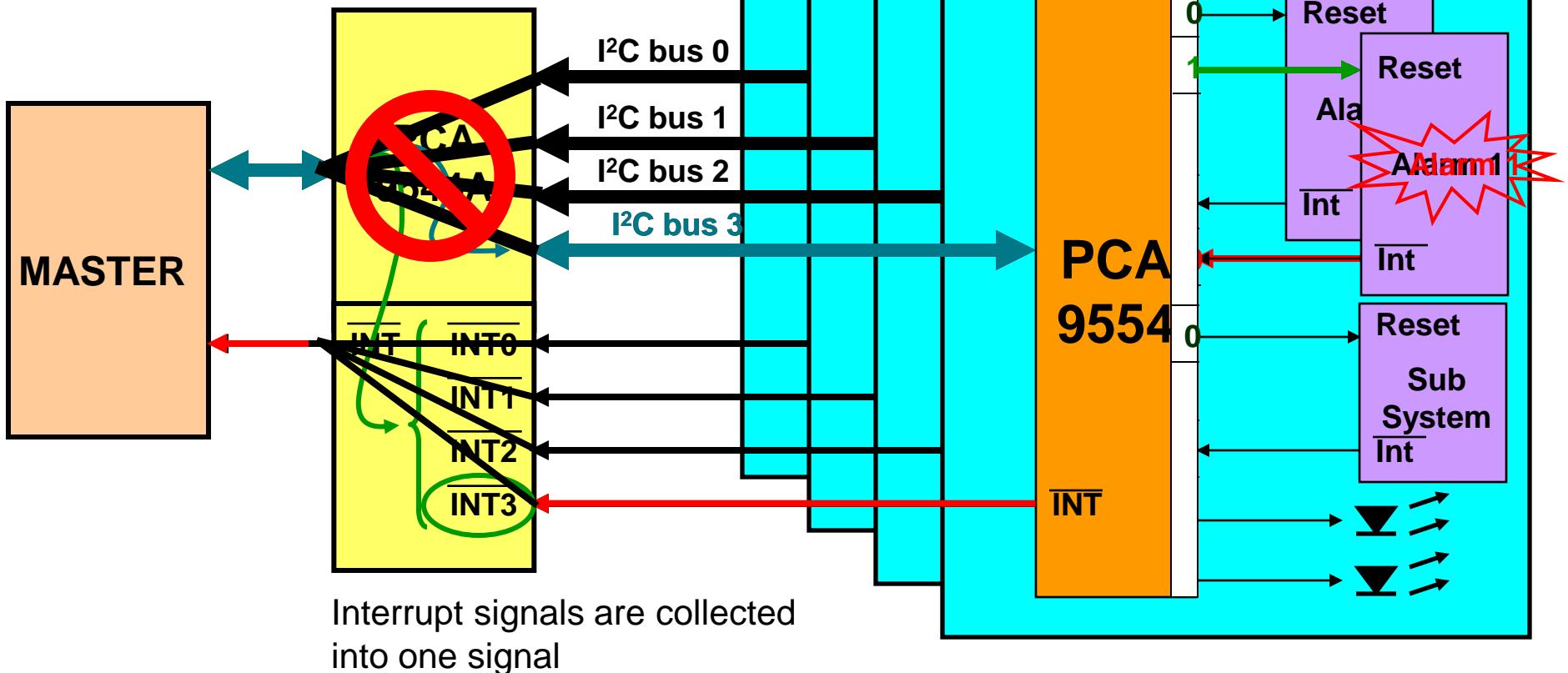- Mux /w Reset
  PCA9547
- Switch /w Reset
  PCA9548A

*   Note: A, B, and C have different I^{2}C fixed address

I²C Multiplexers: Multi-card Application

- Cards are identical
- One card is selected / controlled at a time
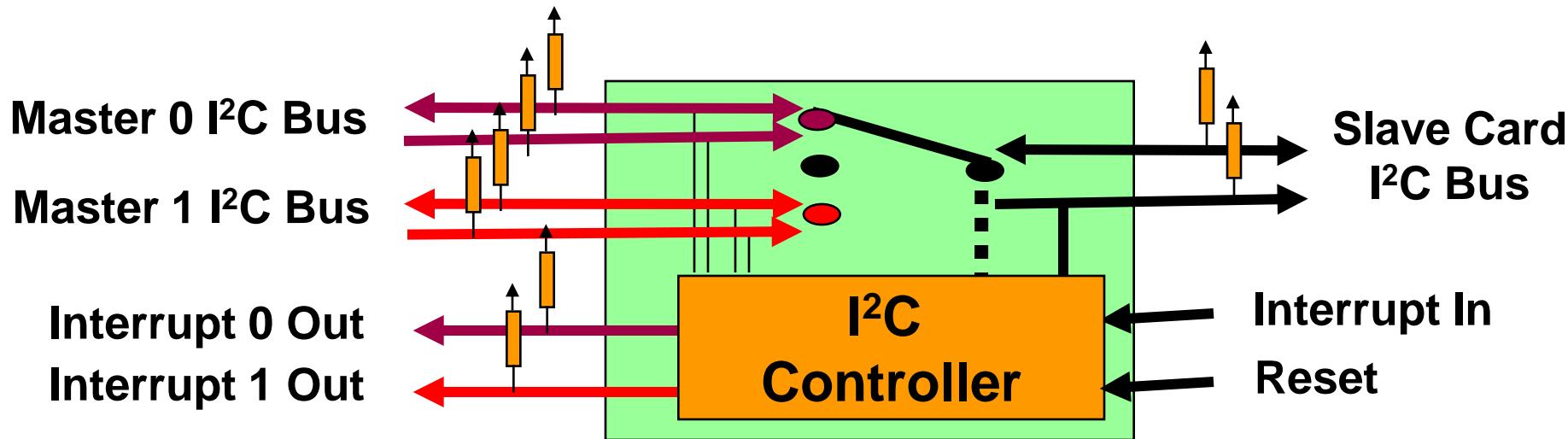- PCA9544A collects Interrupt

Interrupt signals are collected into one signal

Isolate An I²C Hanging Segment

‣ **Isolating individual device becomes very easy for troubleshooting and maintenance.**
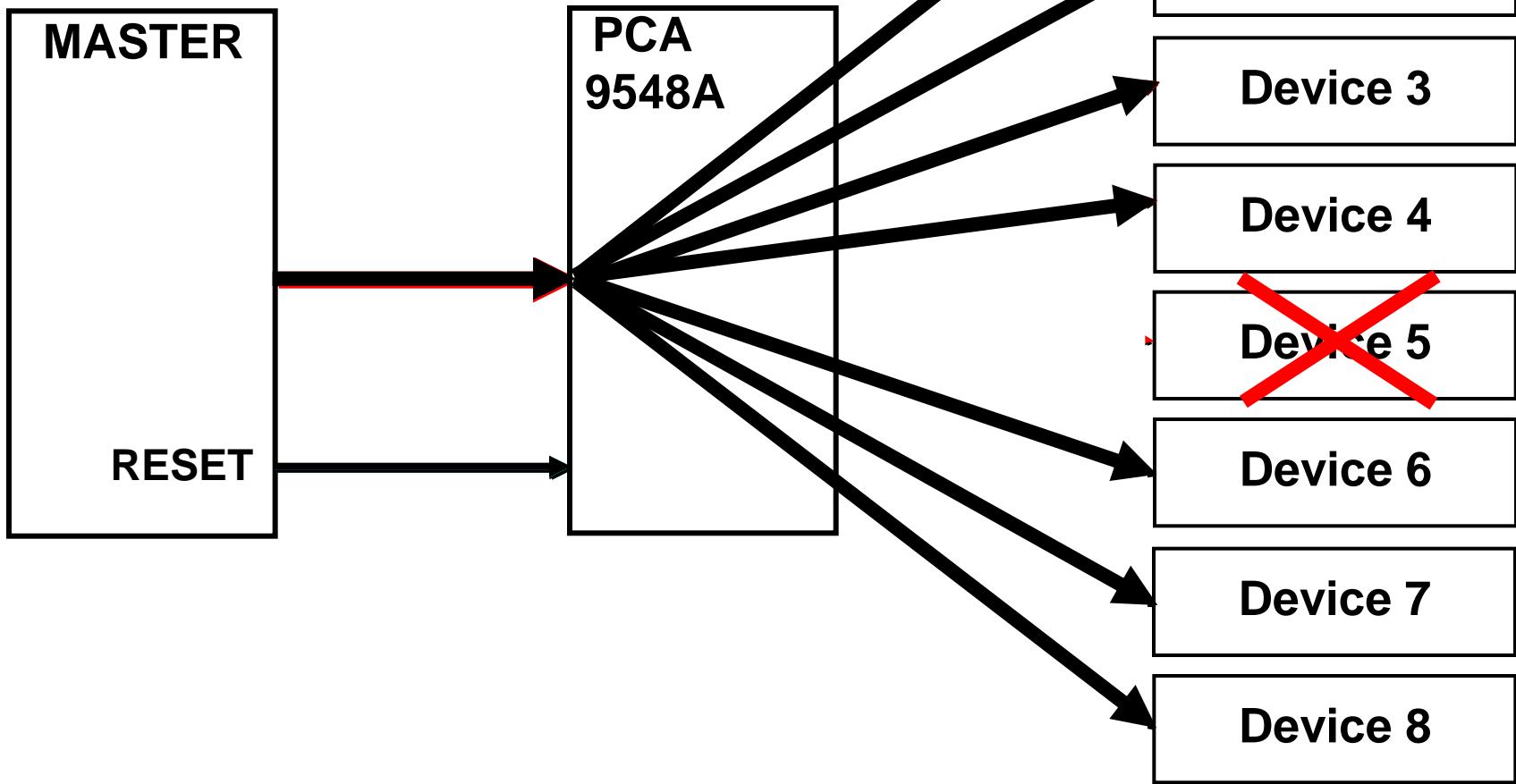
Two to One I²C Master Selector w/Interrupt Logic and Reset

Master 0 I²C Bus

Master 1 I²C Bus

Interrupt 0 Out
Interrupt 1 Out

I²C Controller

Slave Card I²C Bus

Interrupt In

Reset

FEATURES
- Select one of two I²C masters to a single channel
- I²C/SMBus commands used to select channel
- Reset or Power On Reset (POR) resets state machine
- Interrupt outputs also report demultiplexer status
- Sends 9 clock pulses and stop condition to clear slave card prior to transferring master

KEY POINTS
- Allows primary and backup master to communicate to one downstream slave card.
- Arbitration circuit between bus masters
- Doesn't isolate bus capacitance
- Allows voltage translation between 1.8 V, 2.5 V, 3.3 V and 5 V
- Idle detect for live insertion protection

- **PCA9541A/01 - defaults to channel 0 on start-up/reset**

- **PCA9541A/03 – defaults to off on start-up/reset, master commands channel**

Master Selector for Fault Tolerant Application

▸ Problem: Masters may not be multi-master capable or can lock up the bus.

▸ Solution: **PCA9541A**, a master selector, is used to separate the masters and still allow shared access to slave devices.